Danish Strategic Research Center for Energy, Environment and Health (CEEH) and some relevant WMO approaches

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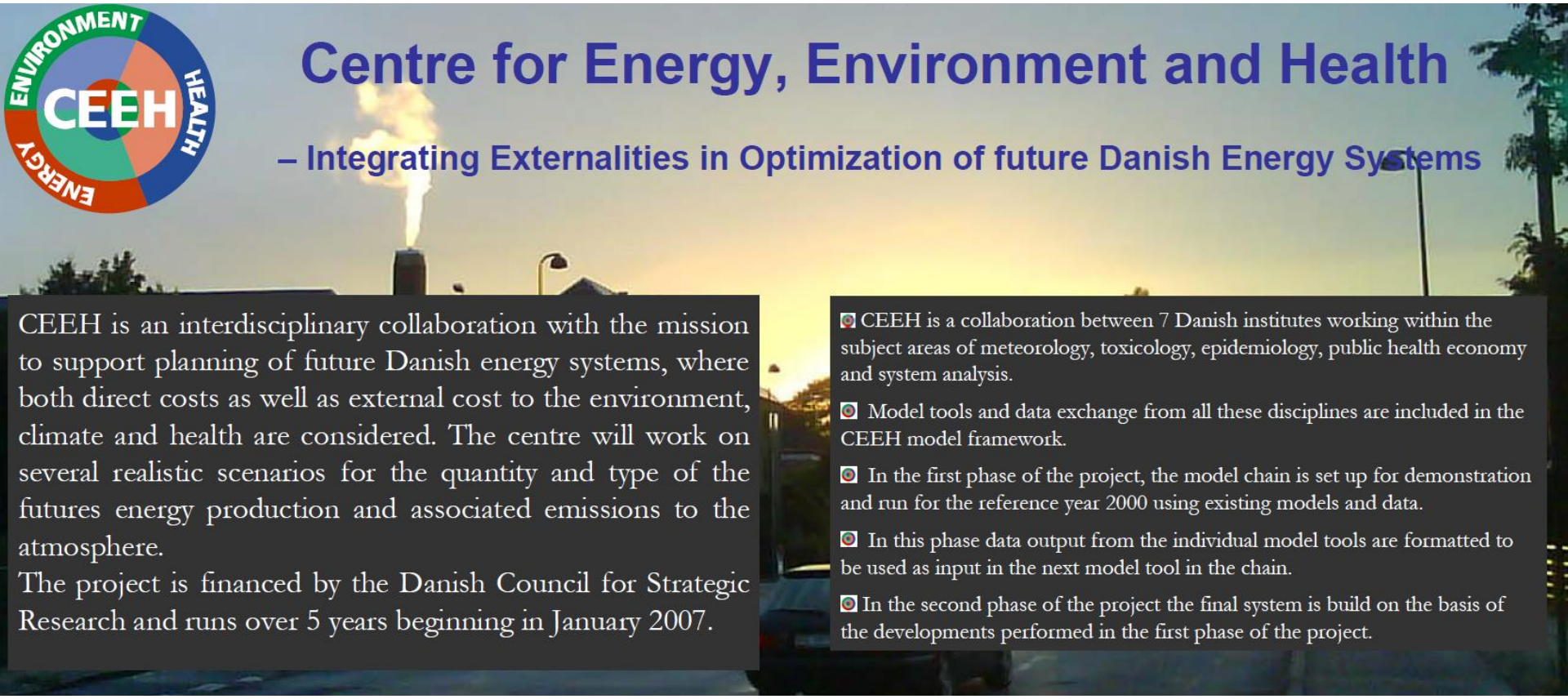
WEATHER CLIMATE WATER
TEMPS CLIMAT EAU

WMO OMM
World Meteorological Organization
Organisation météorologique mondiale

PEEX Workshop
19 February 2021

Energy Environment Health



Centre for Energy, Environment and Health

– Integrating Externalities in Optimization of future Danish Energy Systems

CEEH is an interdisciplinary collaboration with the mission to support planning of future Danish energy systems, where both direct costs as well as external cost to the environment, climate and health are considered. The centre will work on several realistic scenarios for the quantity and type of the futures energy production and associated emissions to the atmosphere.

The project is financed by the Danish Council for Strategic Research and runs over 5 years beginning in January 2007.

- CEEH is a collaboration between 7 Danish institutes working within the subject areas of meteorology, toxicology, epidemiology, public health economy and system analysis.
- Model tools and data exchange from all these disciplines are included in the CEEH model framework.
- In the first phase of the project, the model chain is set up for demonstration and run for the reference year 2000 using existing models and data.
- In this phase data output from the individual model tools are formatted to be used as input in the next model tool in the chain.
- In the second phase of the project the final system is build on the basis of the developments performed in the first phase of the project.

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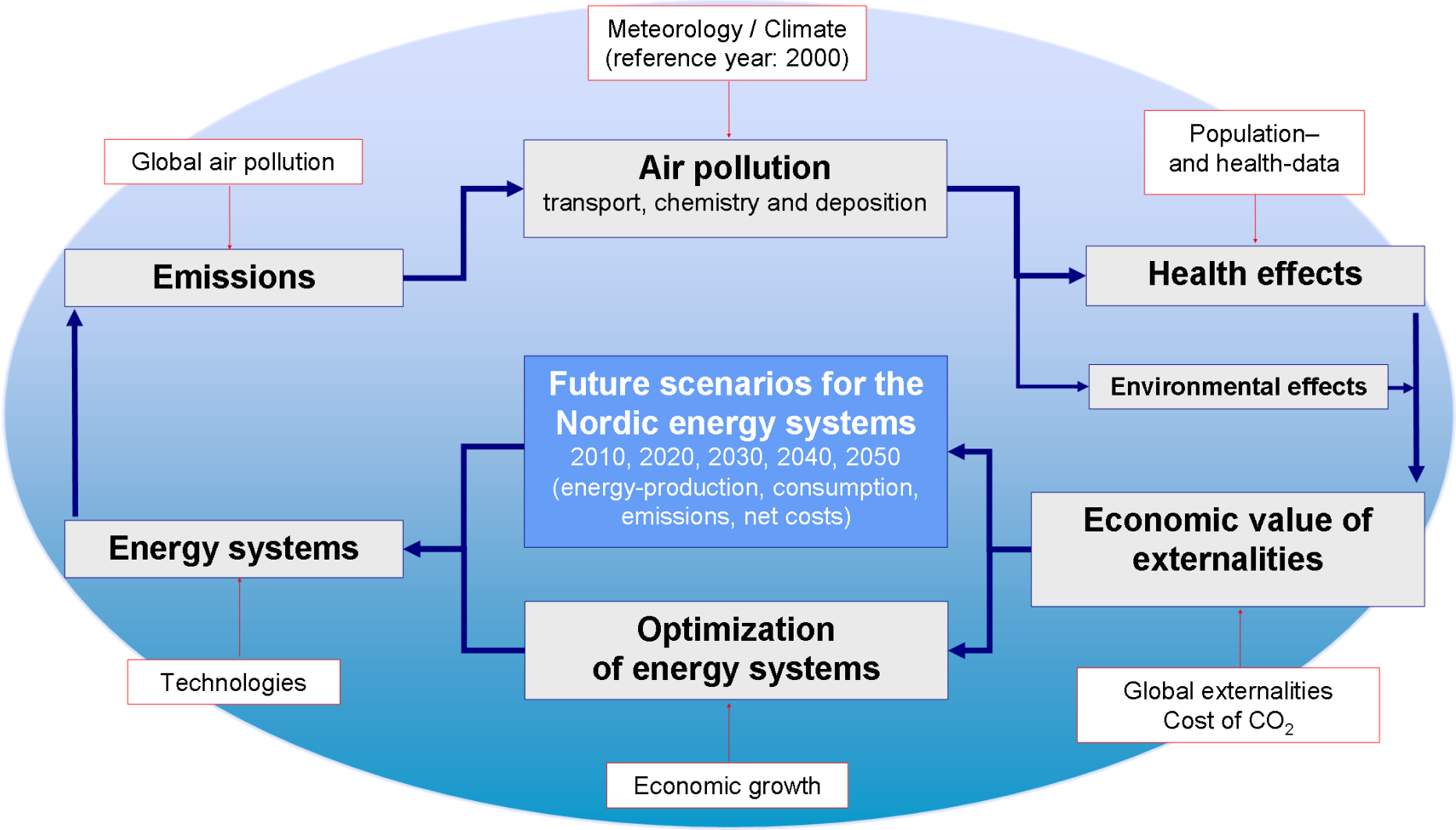
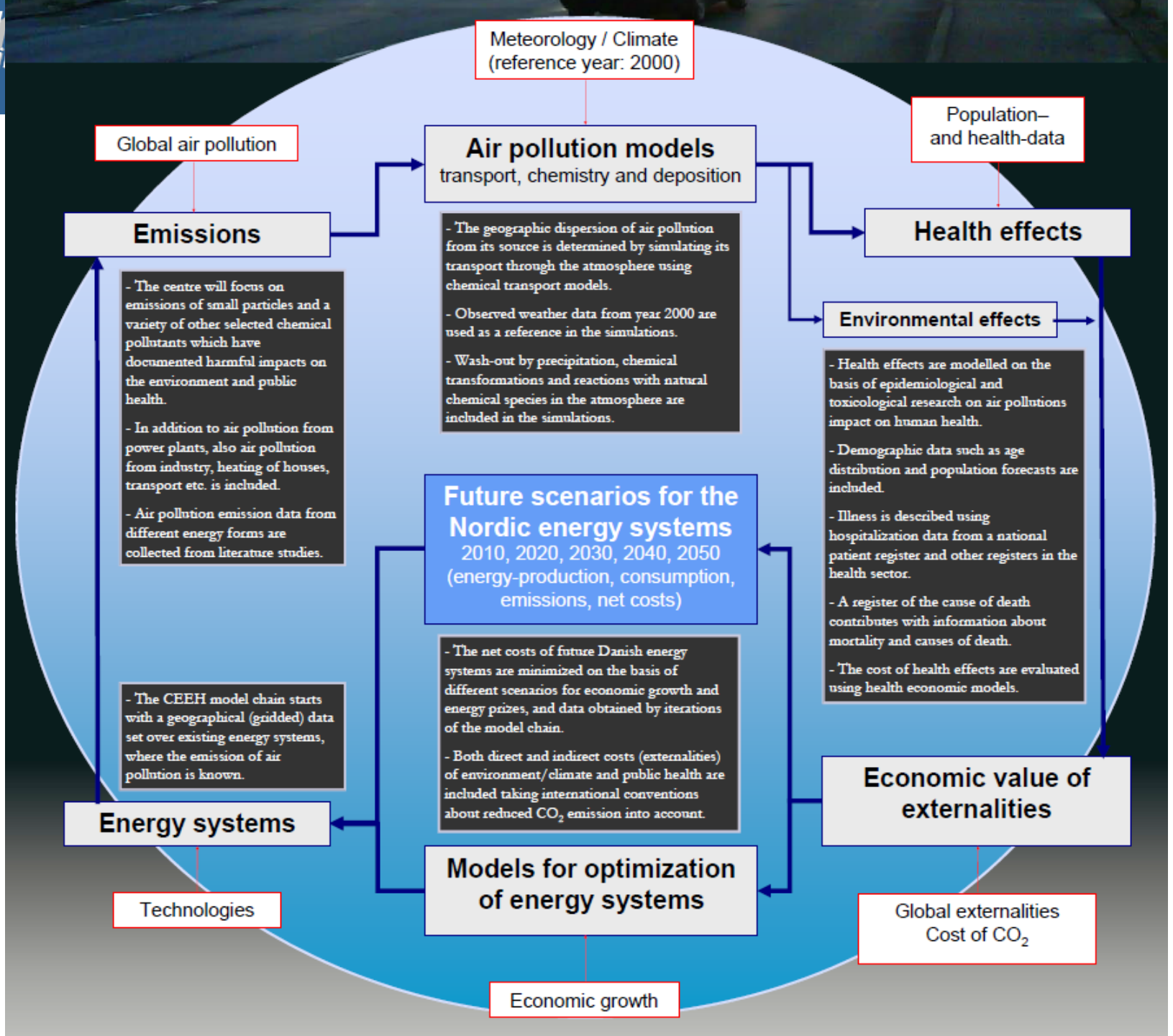
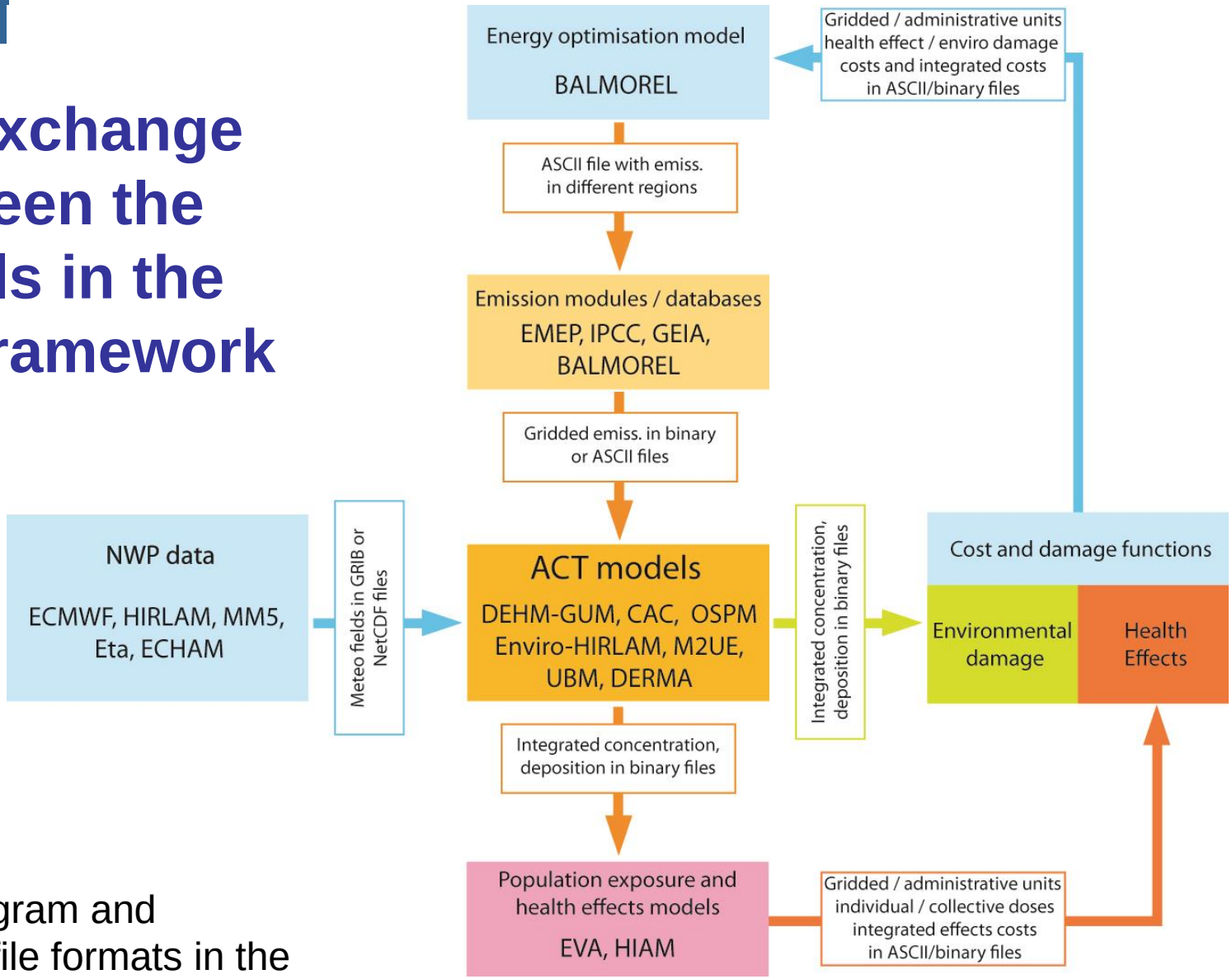
CEEH modelling chain



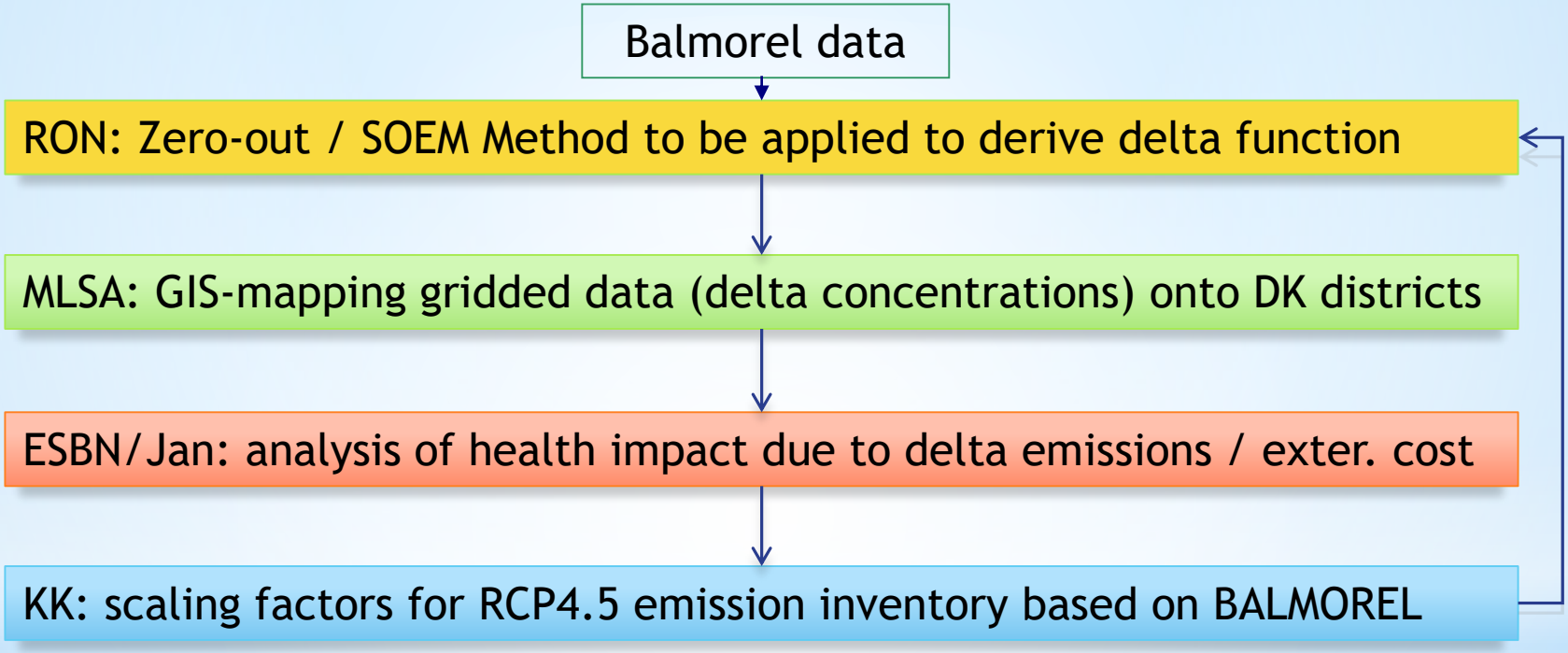

Meteorology / Climate
(reference year: 2000)
Global air pollution
Air pollution models
transport, chemistry and deposition
Population–
and health-data
Emissions
- The geographic dispersion of air pollution from its source is determined by simulating its transport through the atmosphere using chemical transport models.
- Observed weather data from year 2000 are used as a reference in the simulations.
- Wash-out by precipitation, chemical transformations and reactions with natural chemical species in the atmosphere are included in the simulations.
Health effects
Environmental effects
- The centre will focus on emissions of small particles and a variety of other selected chemical pollutants which have documented harmful impacts on the environment and public health.
- In addition to air pollution from power plants, also air pollution from industry, heating of houses, transport etc. is included.
- Air pollution emission data from different energy forms are collected from literature studies.
- Health effects are modelled on the basis of epidemiological and toxicological research on air pollutions impact on human health.
- Demographic data such as age distribution and population forecasts are included.
- Illness is described using hospitalization data from a national patient register and other registers in the health sector.
- A register of the cause of death contributes with information about mortality and causes of death.
- The cost of health effects are evaluated using health economic models.
Future scenarios for the Nordic energy systems
2010, 2020, 2030, 2040, 2050
(energy-production, consumption, emissions, net costs)
- The net costs of future Danish energy systems are minimized on the basis of different scenarios for economic growth and energy prizes, and data obtained by iterations of the model chain.
- Both direct and indirect costs (externalities) of environment/climate and public health are included taking international conventions about reduced CO_2 emission into account.
- The CEEH model chain starts with a geographical (gridded) data set over existing energy systems, where the emission of air pollution is known.
Economic value of externalities
Energy systems
Models for optimization of energy systems
Technologies
Global externalities
Cost of CO_2
Economic growth

Data exchange between the models in the CEEH framework



Dataflow diagram and input/output file formats in the CEEH model framework

Research to be done
(HIA line)



RUNS to be done (by DMI):

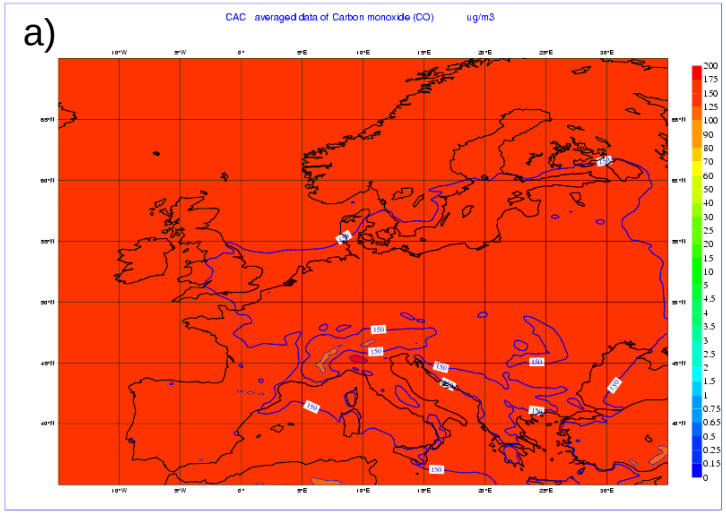
Year by year separately: 2010, 2020, 2030 / maybe - 2040, 2050

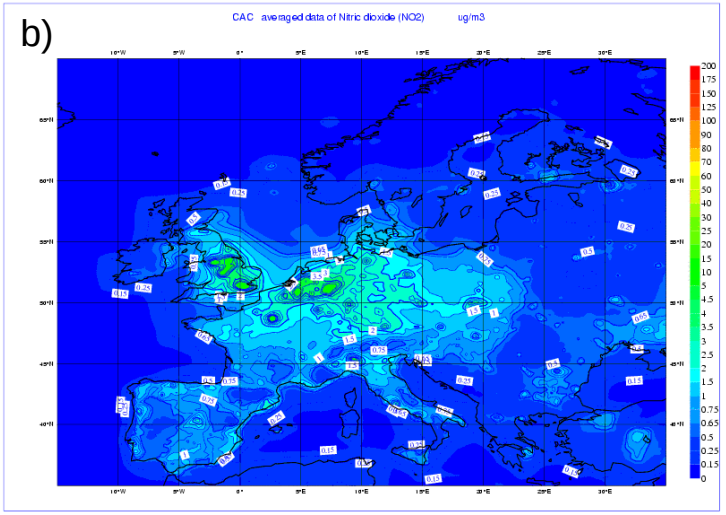
Min 4 runs per year, i.e. **1)** ref. RCP4.5; **2)** scaled emiss. RCP4.5; 3) next iter.?

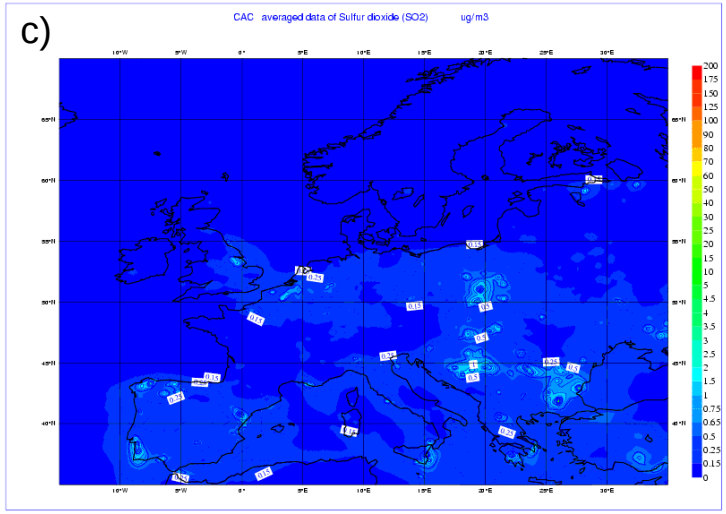
2000 meteorology (NCEP+nested online) + Climate? + NERI chem. BCs + RCP4.5 emis.

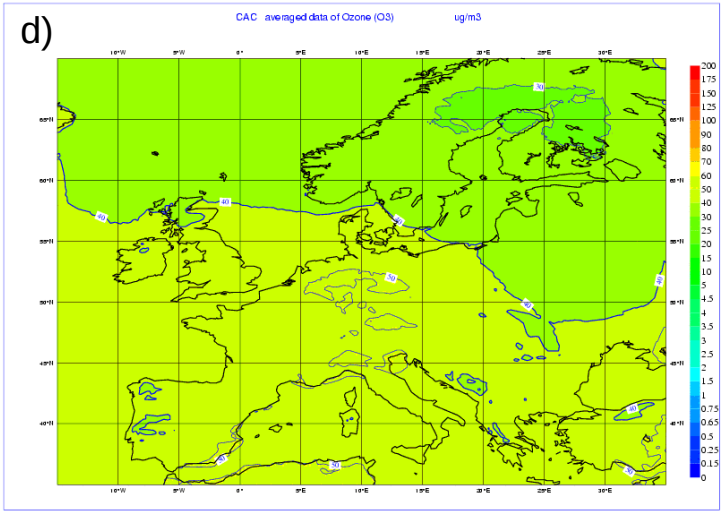
Additionally: model runs for 5 SNAP codes

Long-term run for the reference year 2000









Annual average for the year 2000 of

a) Carbon monoxide

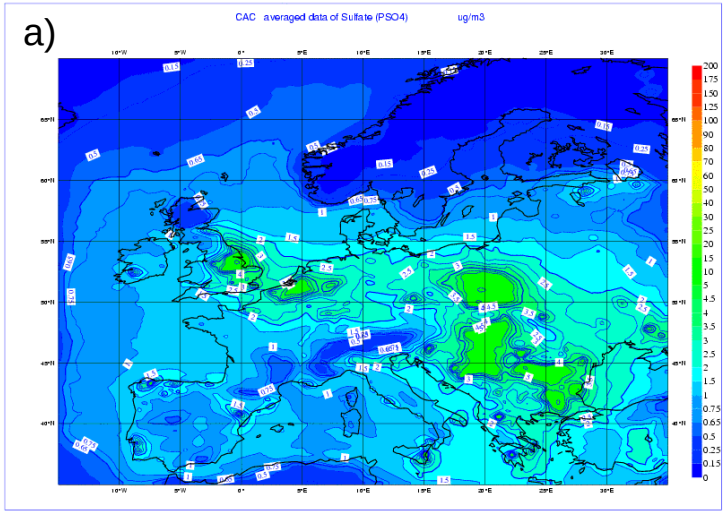
b) Nitric dioxide

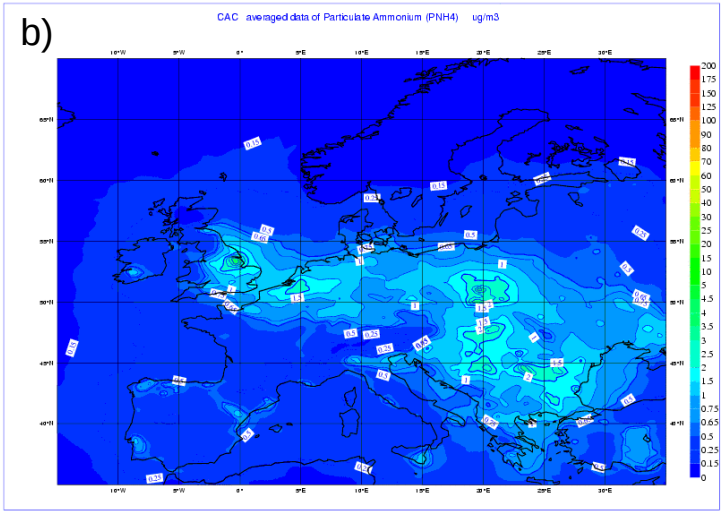
c) Sulfur dioxide

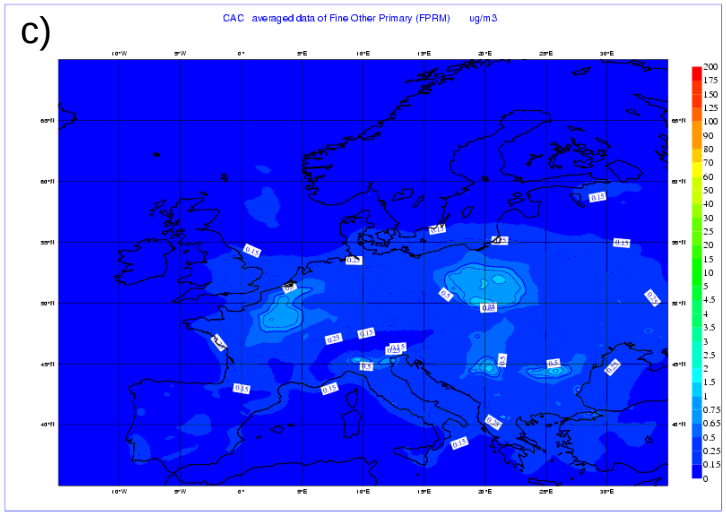
d) Ozone

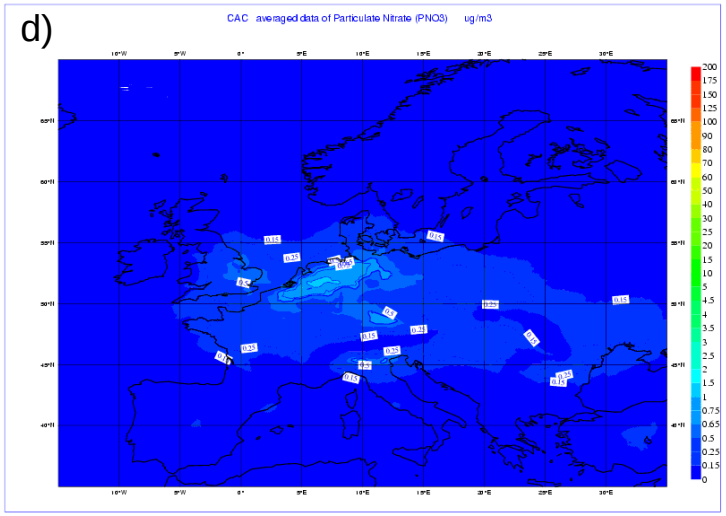
Surface values

Long-term run for the reference year 2000









Annual average for the year 2000 of

a) Sulfate

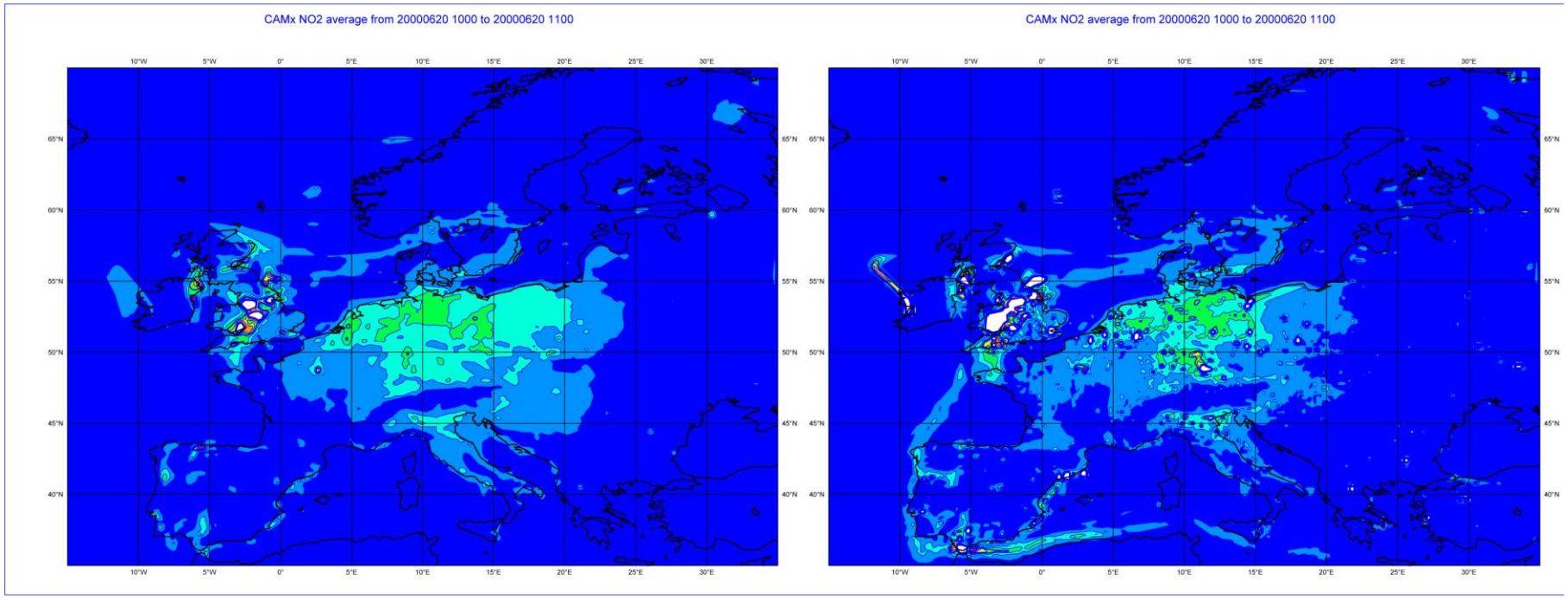
b) Ammonium

c) Fine particles (<=2.5 µm)

d) Nitrate

Surface values

Comparing of CAC runs with EMEP and MEGAPOLI/TNO emission inventories



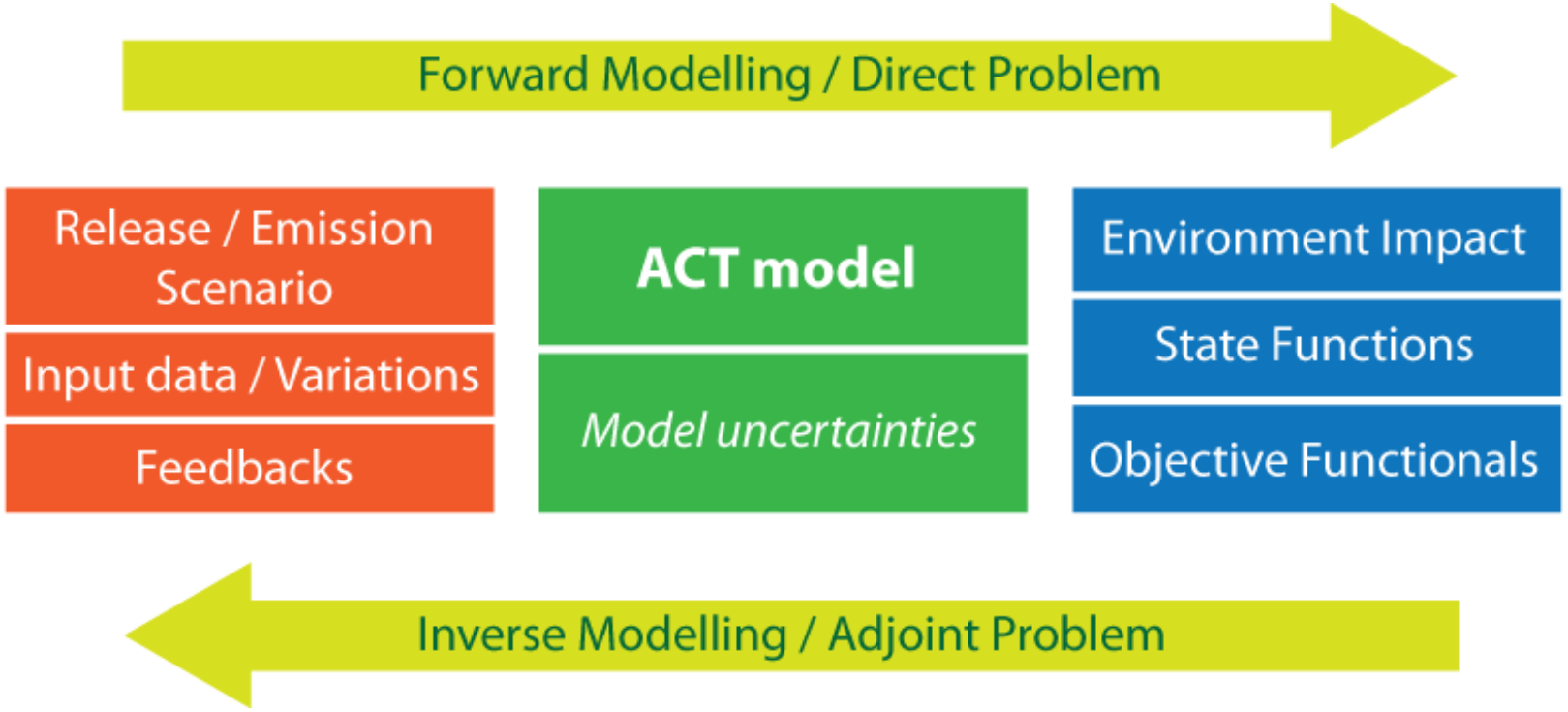
EMEP emission inventory
(50 x 50 km resolution)

TNO/MEGAPOLI emission inventory
(6 x 6 km resolution)

Surface values of nitric dioxide (ppm)

Energy Environment Health

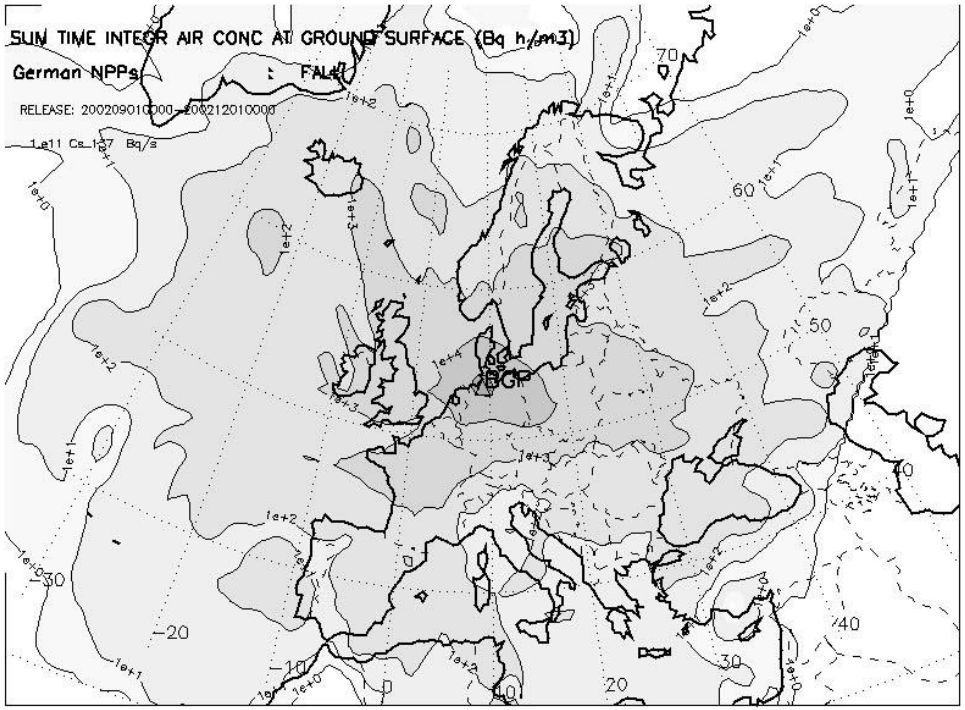
Environmental risk assessments and mitigation strategy optimisation



Probabilistic Risk Assessment of Possible Impact for Copenhagen area from Nuclear Power Plants and Risk Sites

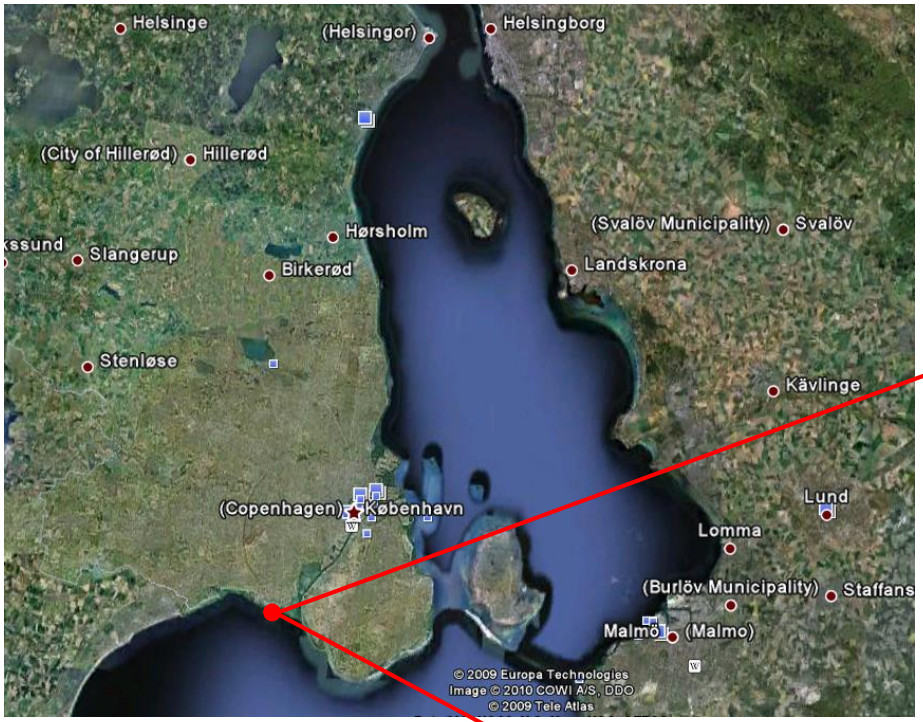
Annual average ^{137}Cs Time-Integrated Air Concentration (TIAC), Dry Deposition (DD), Wet Deposition (WD), and Total Deposition (TD), and relative contribution (WD/TD) of WD into total deposition at Copenhagen, Denmark, resulting from hypothetical releases at selected Nuclear Risk Sites

Copenhagen, Denmark vs. NRS	*Distance to city* (km)	*TIAC* ($Bq \cdot h/m^3$)	*DD* (Bq/m^2)	*WD* (Bq/m^2)	*TD* (Bq/m^2)	*WD/TD* (%)
BNP – Barsebäck NPP, Sweden	*28*	1.92E+3	1.04E+4	1.68E+4	2.72E+4	*62*
RNP – Ringhals NPP, Sweden	*234*	1.95E+2	1.05E+3	8.82E+2	1.93E+3	46
ONP – Oskarshamn NPP, Sweden	*298*	1.73E+2	9.32E+2	1.59E+3	2.53E+3	*63*
BGP – German NPPs, Germany	*334*	1.16E+2	6.27E+2	1.97E+3	2.60E+3	*76*
FNP – Forsmark NPP, Sweden	*623*	4.34E+1	2.35E+2	1.68E+2	4.03E+2	42
TRS – Olkiluoto NPP, Finland	*828*	2.42E+1	1.31E+2	2.50E+2	3.80E+2	*66*
INP – Ignalina NPP, Lithuania	*842*	2.33E+1	1.26E+2	2.34E+2	3.60E+2	*65*
LRS – Loviisa NPP, Finland	*976*	2.54E+1	1.37E+2	2.98E+2	4.35E+2	*68*
BBP – British NPPs, UK	1029	2.35E+1	1.27E+2	3.40E+2	4.67E+2	*73*
LNP – Leningrad NPP, Russia	1077	1.50E+1	8.10E+1	7.68E+1	1.58E+2	49
SNP – Smolensk NPP, Russia	1231	5.10E+0	2.76E+1	4.20E+1	6.96E+1	*60*
CNP – Chernobyl NPP, Ukraine	1261	7.34E+0	3.96E+1	9.70E+1	1.37E+2	71
KNP – Kola NPP, Russia	1697	3.58E–1	1.93E+0	1.00E+0	2.93E+0	34
KNS – Kola NS, Russia	1827	3.08E–1	1.69E+0	8.27E–1	2.52E+0	33
NZS – Novaya Zemlya, Russia	2665	1.51E–3	8.14E–3	3.56E–2	4.37E–2	*81*



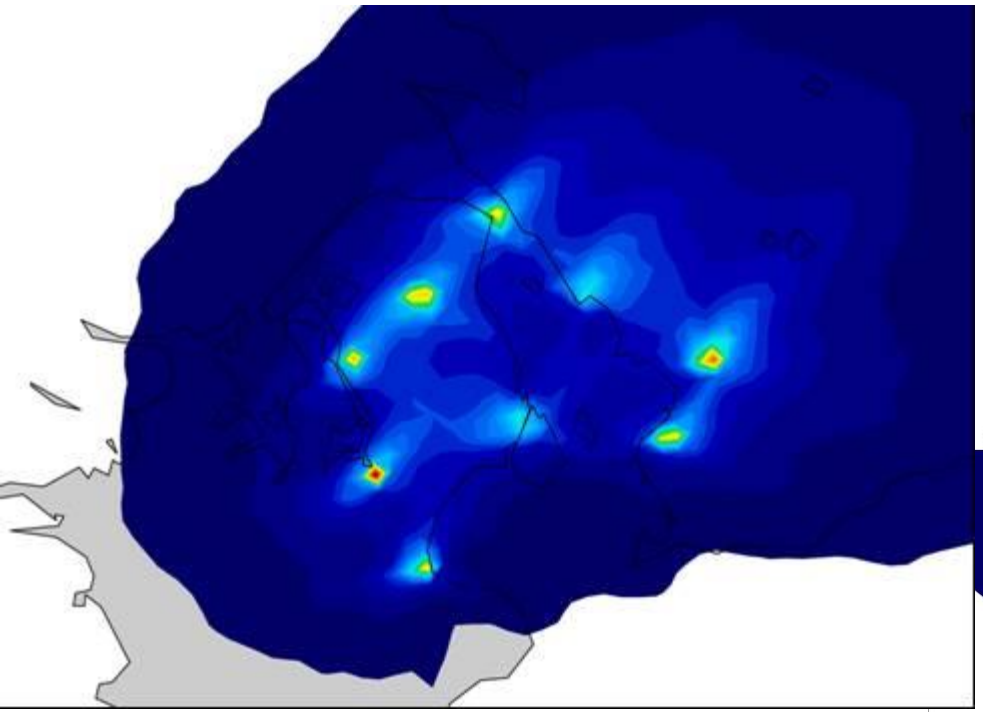
(Mahura et al., 2009)

Adjoint model for optimization of place and parameters of power plant



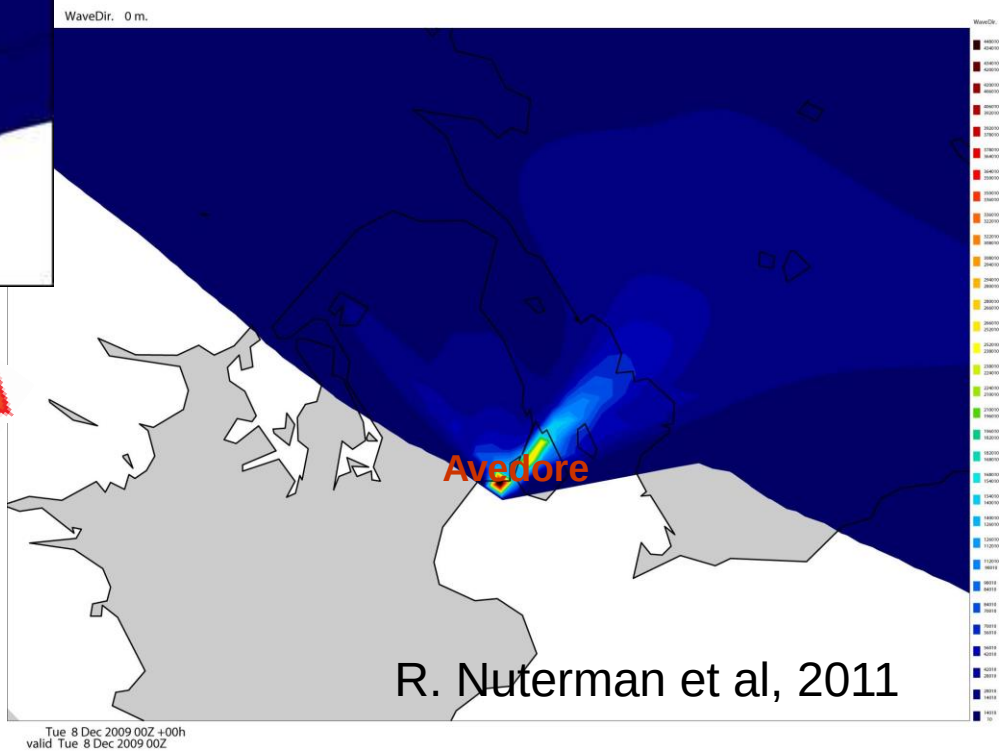
Avedore Multi-Fuel Power Plant

Adjoint model for optimization of place and parameters of power plant



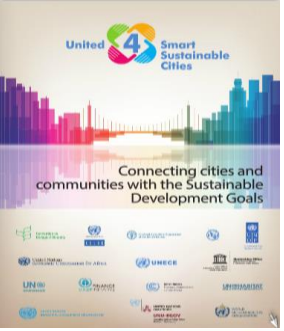
Backward runs

Forward run



Assessment of areas with high potential risk and vulnerability with respect to nine cities (receptors) of Denmark (Copenhagen, Frederikssund, Helsingør, Hillerød, Køge and Roskilde) and Sweden (Malmo, Landskrona and Lund)

R. Nuterman et al, 2011



Climate smart and sustainable cities

SUSTAINABLE DEVELOPMENT GOAL 11

Make cities and human settlements inclusive, safe, resilient and sustainable

Resilient

Sustainable

Multi-Hazard Early Warning Systems for Weather, Hydrology, Air Quality at Urban Scales

Long Term Planning
Climate Services for Weather, Hydrology and Air Quality at Urban Scales

World Meteorological Organization
Weather · Climate · Water

Goal: Science-based Integrated Urban Hydro-Meteorological, Climate and Environmental Services (IUS)

Benefits of IUS - Useful, Usable, Used

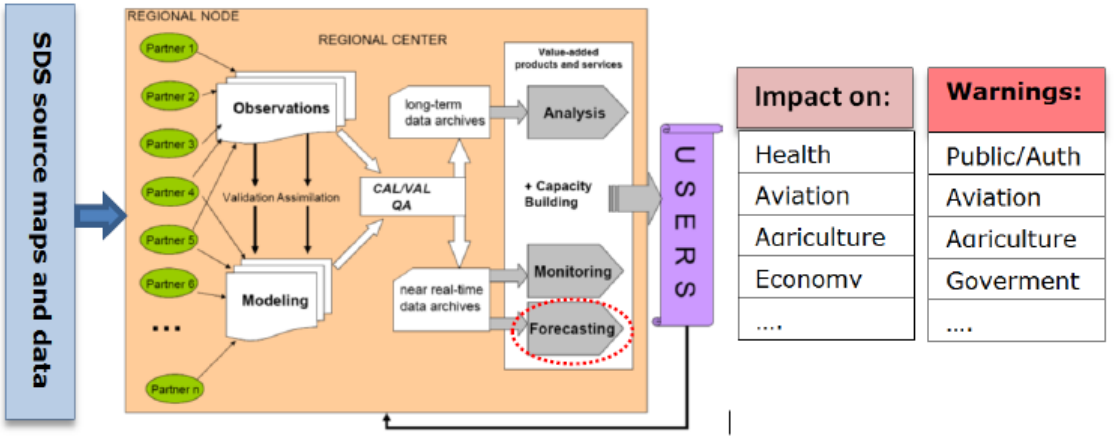
1. Resiliency through Multi-Hazard Early Warning Systems
2. Sustainability through urban long term planning
3. Capability and capacity through cross-cutting services
4. Efficiency through infrastructure cross-cutting services
5. Consistency (hence, effective and efficient) through integration
6. Effective service through Partnerships / Risk Communication

SDS-WAS Extension to Impact based assessment and combating SDS risk

Joint and coordinated efforts of several UN Agencies (e.g., WMO, UNEP, UNCCD, WHO), National Authorities and Research community are needed

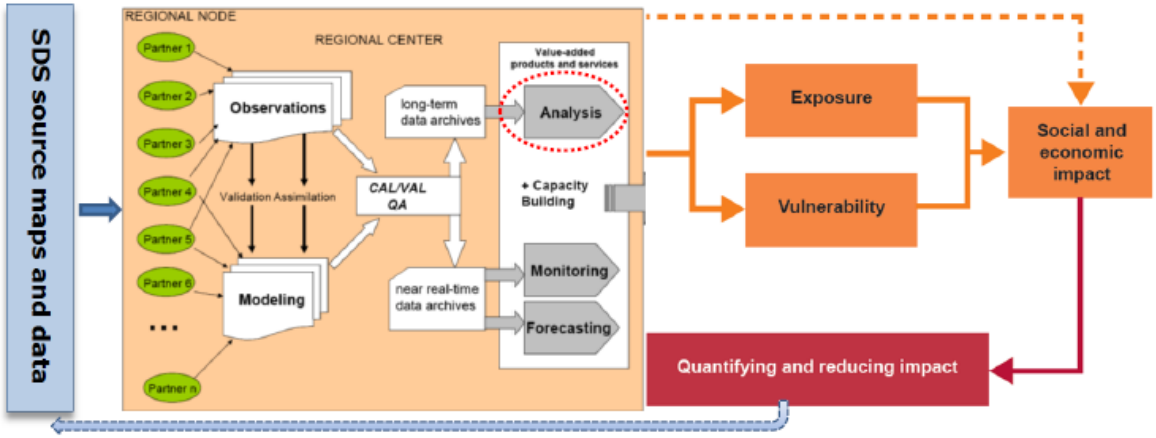
WMO Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS) for UN SDS Coalition

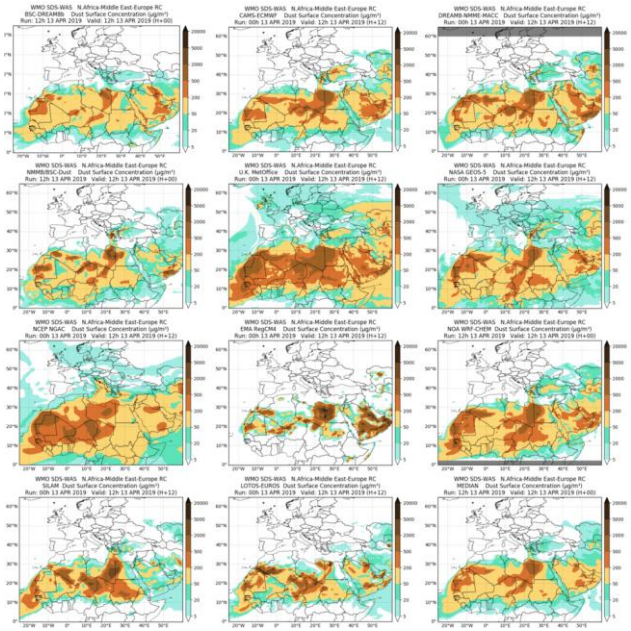
SDS-WAS for Forecasting and Early Warning:



- 9 global models
- 15 regional models
- > 30 organizations
- 3 regional nodes & centers (*NAMEE, Asia, Americas*)
- 2 regional dust operational centers (*Barcelona and Beijing*)
- Several national centers

SDS-WAS for Impact Assessment:



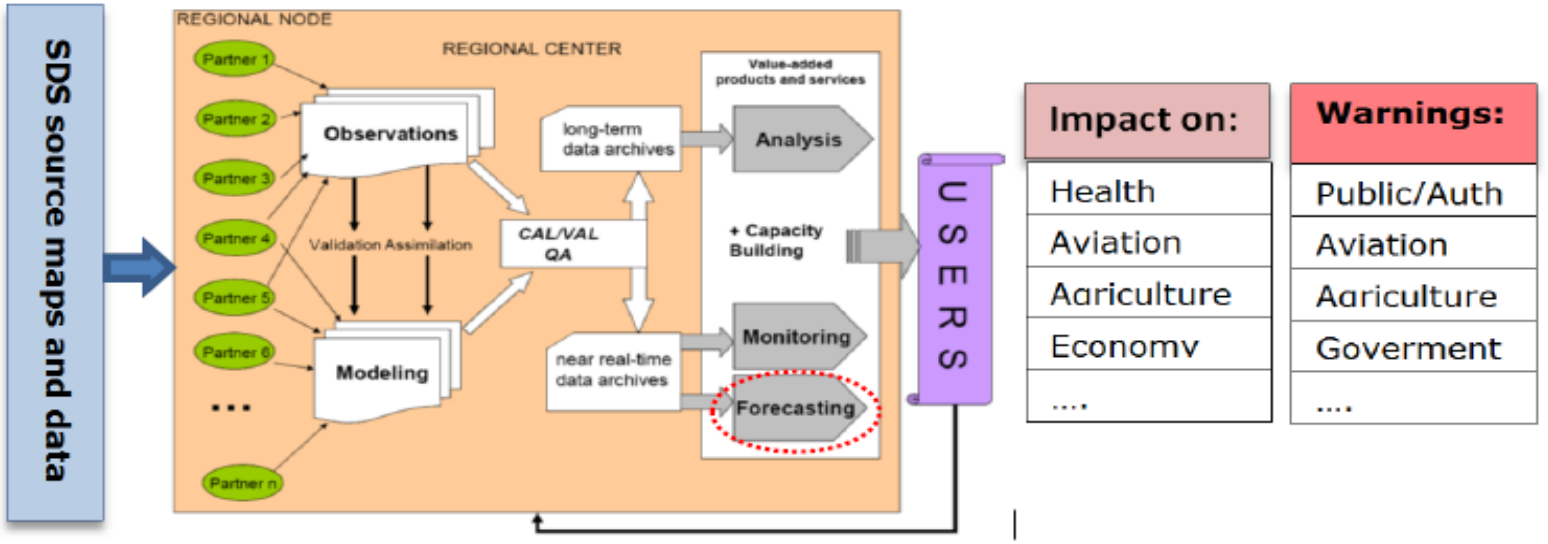


Joint and coordinated efforts of several UN Agencies (e.g., WMO, UNEP, UNCCD, FAO, WHO, ESCAP), National Authorities and Research community are needed

WMO

Fit for purpose & Impact based forecast

- There are also several user communities (e.g., NWP, climate) and specialized applications of such system developments for long-term prediction and specific episodes of atmospheric harmful contamination, affecting not only health but many other sectors of economics.
- Example of impact-based forecast and assessment systems for the WMO Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS) (after Nickovic et al., 2015).



- Help stakeholders and responsible agencies to improve AQ and public health, mitigate occurrence of acute harmful AP episodes.

SDS: Economic Impact & DRR

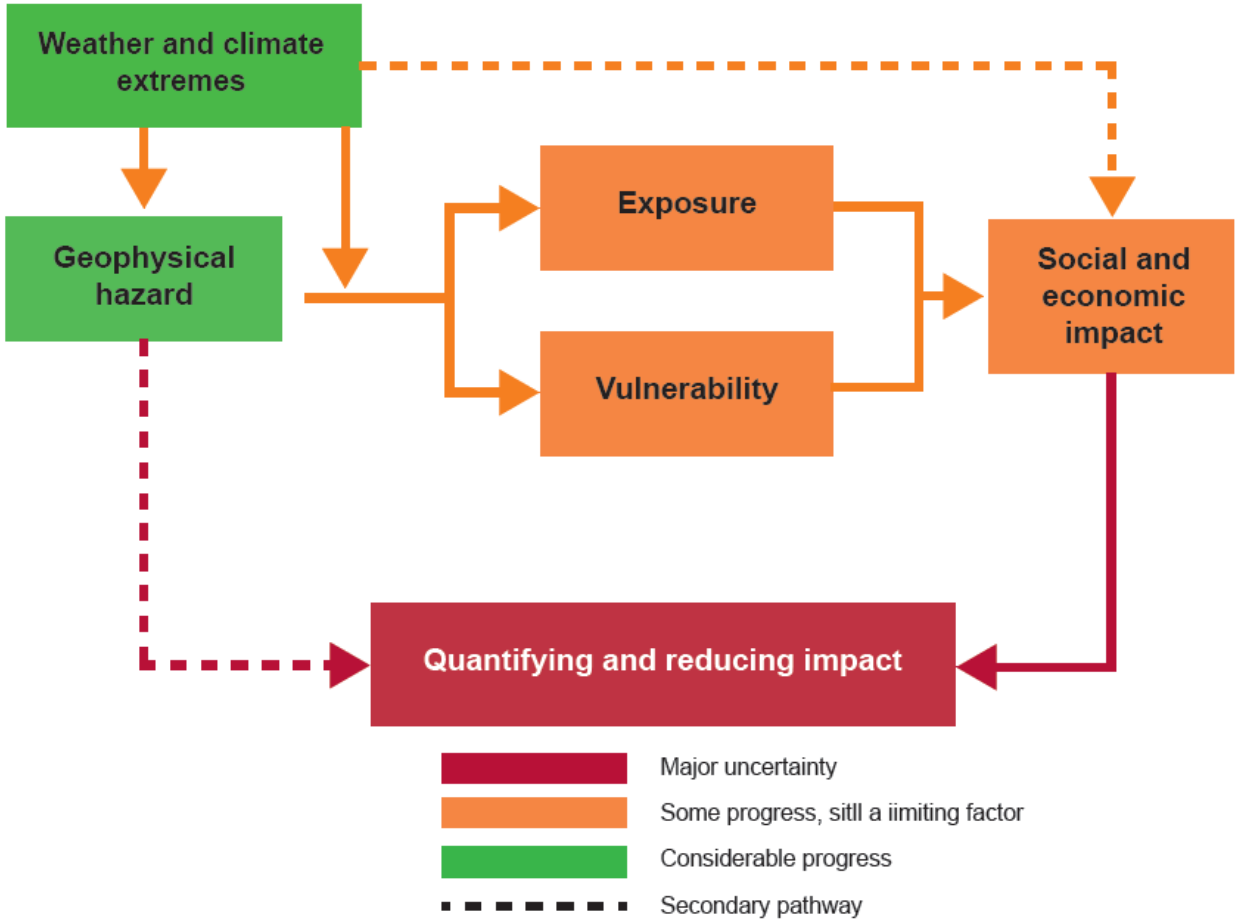
Short-term costs:

- Livestock mortality, crop damage, infrastructure damage, transport and communications disruption, effects on energy and clear industry, costs of clearing sand and dust.

Longer-term costs:

- Soil erosion and reduced soil quality, soil pollution through deposition of pollutants, and disruption of global climate regulation.
- Economic losses from a single event can be in the order of hundreds of million dollars, but benefits rarely quantified.

(UNEP, WMO, UNCCD 2016)



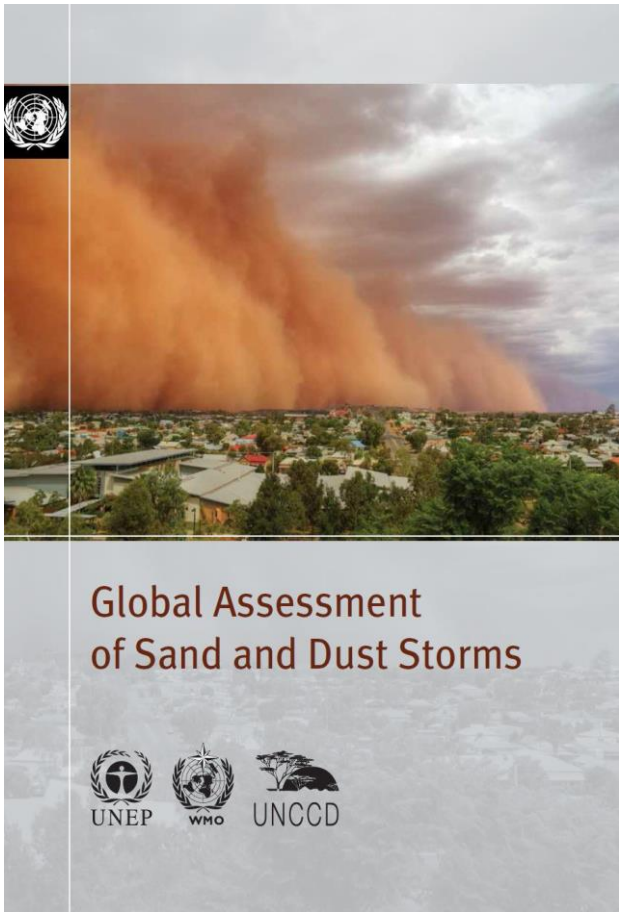
(WMO MHEWS, 2017)

WMO OMM

Policy framework for mitigation of SDS

(UNEP, WMO, UNCCD 2016)

1. **Measures to reduce anthropogenic emissions**
   a. Sustainable land and landscape management
   b. Climate change mitigation and adaptation
2. **Physical protection of valuable assets, such as towns, infrastructure, and irrigation schemes**
   a. Reducing wind speed through tree planting around urban areas and infrastructure to deposit sand and trap dust outside these areas
   b. Aerodynamic methods to prevent sand and dust accumulation, such as alignment of roads, removal of obstacles to wind and land shaping
3. **Monitoring, prediction and warning systems for sand and dust storms**
   a. Monitoring of SDS through ground networks of meteorological and air quality monitoring stations, and combined use of satellite data
   b. Sand and dust storm forecasting and early warning systems, including mapping of trends and future scenarios of anthropogenic dust sources
4. **Preparedness and emergency response procedures**
   a. Preparedness and emergency procedures for coping with sand and dust storm events (e.g., for airport, rail and road closures; hospital emergency services; advisory communications to public services)
   b. Public awareness of sand and dust storm risks (via education, media and social networks and telecommunication) and emergency procedures
   c. Mainstreaming sand and dust storms into disaster risk reduction and emergency response measures
5. **Policies, legal frameworks and action plans to support the above actions**
   a. International environmental law and initiatives (e.g., SDS-WAS)
   b. Regional frameworks, agreements and action plans
   c. National action plans
6. **Research to reduce critical uncertainties**
   a. Improved knowledge on the interaction of dust with biogeochemical global systems and climate systems
   b. Improved methods for monitoring, prediction and early warning systems
   c. Assessing the impacts and costs of SDS at local to global scales



CEEH Scientific Reports

- Report no 1. Description of the CEEH integrated 'Energy-Environment-Health-Cost' modelling framework system. Jan 2011. ISSN 1904-7495 (100%) http://www.ceeh.dk/CEEH_Reports/Report_1/CEEH_Report_1_Interim_version.pdf
- Report no 2. The CEEH version of Balmorel and its applications. Planned Oct 2012. ISSN 1904-7495 (100%)
- Report no 3. Assessment of Health-Cost Externalities of Air Pollution at the National Level using the EVA Model System. Mar 2011. ISSN 1904-7495 (100%) http://www.ceeh.dk/CEEH_Reports/Report_3/CEEH_Scientific_Report3.pdf
-
- Report no 4. Demonstration of full CEEH chain – the EVA line. Planned Oct 2012. ISSN 1904-7495 (100%)
- Report no 5. Description of the HIA line in the CEEH integrated modeling chain. Sep 2012. ISSN 1904-7495 (100%) http://www.ceeh.dk/CEEH_Reports/Report_5/CEEH_Report5_version_17_09_2012.pdf
- (Report no 6. Demonstration of full CEEH chain – the HIA line). This planned report has been cancelled since the content is covered in reports 5 and 8).
- Report no 7. Description of the CEEH health effects model - selection of concentration-response functions. Nov 2011. ISSN 1904-7495. (100%) http://www.ceeh.dk/CEEH_Reports/Report_7a/CEEH_Report_7a.pdf
- Report no 8. Economically optimized future energy systems in Denmark, and their impacts on health. Planned Nov 2012. ISSN (100%)
- Report no 9. Extended abstracts from International conference on Energy, Environment and Health – Held by CEEH, REBECa and CEESA July 2011. ISSN 1904-7495 (100%) http://www.ceeh.dk/CEEH_Reports/Report_9/CEEH_Scientific_report_9.pdf
- Report no 10. CEEH's beregninger af helbredsomkostninger fra luftforurening i Klimakommissionens scenarier (in Danish) Nov 2011. ISSN 1904-7495 (100%) http://www.ceeh.dk/CEEH_Reports/Rapport_10/CEEH_Rapport_10.pdf