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Data assimilation challenges

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ASSET
Assimilation of Envisat Data

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Recent developments

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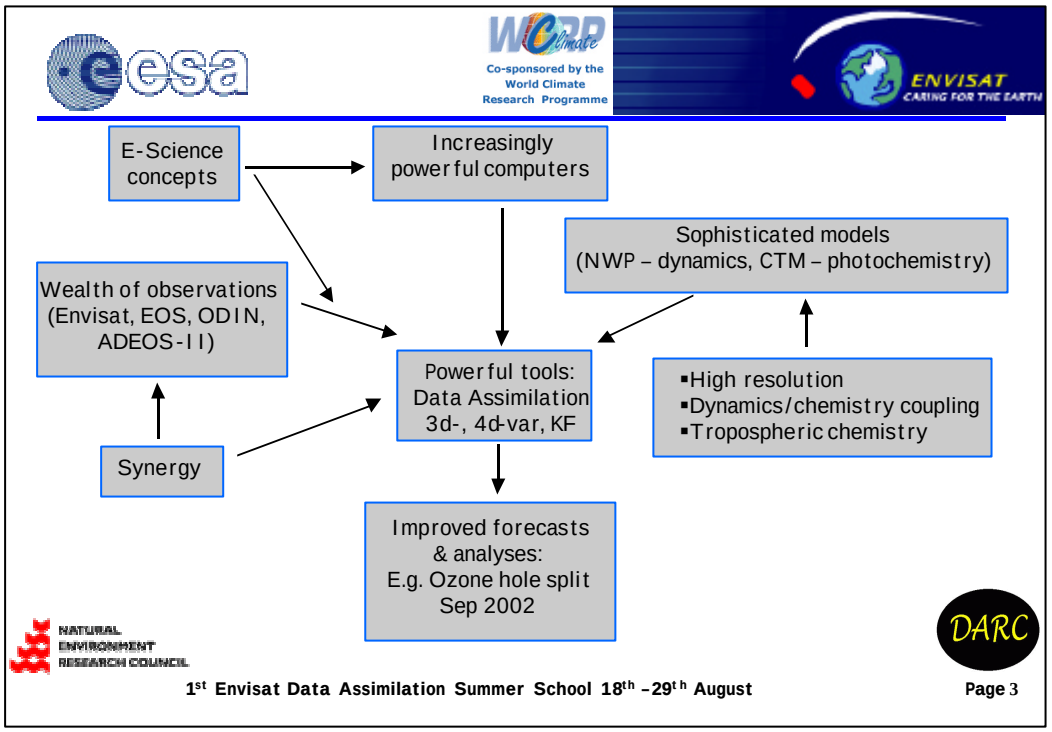
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E-Science concepts
Increasingly powerful computers
Sophisticated models (NWP – dynamics, CTM – photochemistry)
Wealth of observations (Envisat, EOS, ODIN, ADEOS-II)
Powerful tools: Data Assimilation 3d-, 4d-var, KF
▪High resolution
▪Dynamics/chemistry coupling
▪Tropospheric chemistry
Synergy
Improved forecasts & analyses: E.g. Ozone hole split Sep 2002
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A big challenge that cuts across all aspects of data assimilation->

Characterization of errors:

1. Background errors (B): How to compute? How to model space/time distribution?
2. Bias (observations): How to compute? What independent data?
3. Model errors (e.g. bias): confront & evaluate models (e.g. climate models) with data assimilation techniques

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How to make best use of observations?

1. novel geophysical parameters (e.g. aerosol, $ClONO_2$, winds)
2. novel data types (e.g. limb radiances)
3. novel measurement geometries (limb sounders)
4. synergy from measurement geometries (nadir/limb geometries, e.g. MIPAS/SCIAMACHY) -> extend domain of observations to UTLS & troposphere
5. synergy from different instruments (e.g. AATSR/SCIAMACHY)

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How to make best use of data assimilation?

1. data cal-val (self-consistency; data monitoring) -> quality-controlled datasets for use by scientists, public, …
2. confront & evaluate models -> assess climate models
3. analyses of key species (e.g. water vapour in the UTLS & stratosphere)
4. unobserved species (e.g. photochemical species via the model equations)
5. assess future space missions; evaluate current space missions -> protect investment

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How to extend current model/assimilation systems?

1. dynamics/chemistry coupling -> what is the best approach for NWP, research?
2. tropospheric chemistry -> pollution forecasting
3. build toward an Earth System approach -> extend expertise in atmosphere/ocean to e.g. land and biosphere; include feedbacks

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How to make best use of resources?

1. **Training -> use & familiarity with data assimilation tools & EO data: NATO ASI, 1st Envisat DA Summer School**
2. **Collaboration -> workshops, visits, projects (co-ordination): knowledge & issues are world-wide**
3. **Links between met agencies & space agencies & the research community: extend & exchange knowledge**
4. **Links between operational & research communities & the wider community (public, government, commercial): best use of information**

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How to make information accessible?

1. **information management & dissemination -> need for standard formats; need for user flexibility; need for a user-friendly interface; proper documentation**
2. **access beyond scientists: public, commercial users, governments,… -> "rules of the road"?; links between scientists, met agencies, space agencies & the commercial sector; commercial exploitation**

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Example of how some of these challenges are being met:

The ASSET (ASSimilation of Envisat daTa) consortium

- U. Reading/Met Office: stratospheric water vapour assimilation(*)
- Météo-France/CERFACS: Coupled dynamics/chemistry assimilation(*)
- ECMWF: Limb radiances(*)
- KNMI: Synergy from measurement geometries
- UPMC: Assimilation of novel photochemical species
- BIRA-IASB: stratospheric aerosol
- U. Köln/U. Karlsruhe: Tropospheric chemistry/novel retrievals
- CNR.IFAC: Tomographic retrievals
- NILU: Data management

ASSET is a FP5 project: http://darc.nerc.ac.uk/asset

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Assimilation of water vapour in stratosphere

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Water vapour:

Radiation: Dominant GHG in atmosphere

Dynamics: Diagnostic of atmospheric circulation

Chemistry: Source of OH; PSCs

See "SPARC Assessment on Upper Tropospheric & Stratospheric Water Vapour" (2000)

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Assimilation of UT/S data from Envisat (H_2O, as well as CH_4) will help address many of the recommendations in the SPARC assessment: validation, monitoring, more observations, continuity of measurements

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Challenge:

Large variation between troposphere & stratosphere ->

characterization of errors (e.g. B matrix)

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Coupled dynamics/chemistry in assimilation schemes

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Approaches to assimilation:

- GCM: dynamics with "simple" chemistry (Cariolle) (U.Reading/Met Office, ECMWF)
- CTM: sophisticated photochemistry driven by off-line winds / temp (KNMI, UPMC, BIRA-IASB, U.Köln)
- Coupled GCM/CTM (time-step?): Get the best from above approaches (Météo-France/CERFACS)

Recent developments in assimilation for GCMs & CTMs feed into coupled dynamics / chemistry assimilation

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Challenge:

How best to incorporate dynamics & chemistry efficiently & accurately

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Limb radiance assimilation

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Why?

Better to assimilate information nearer in form to data received by instrument (i.e. radiances instead of retrievals)

Overcomes shortcomings associated with retrievals:

1) need to include *a priori* information to make problem well-posed & fill in data gaps – "contamination" of solution

2) common assumption that measurement errors uncorrelated (expediency) not strictly true for retrievals.

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Some challenges:

- Limb geometry
- Computationally feasible forward model for IR limb radiances
- Data volumes
- Error characteristics

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Future directions

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- Characterization of errors: cuts across data assimilation
- Operational use of research satellite data by NWP centres: ozone (already assimilated at ECMWF), stratospheric H_2O
- Assimilation of limb radiances by research/operational groups
- Chemical forecasting & tropospheric pollution forecasting
- Coupled dynamics/chemistry DA systems (e.g. GCM/CTM)
- Earth System approach to environmental & socio-economic issues
- Management/dissemination/exploitation of value-added information

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and...

TRAINING

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