Data Assimilation at DWD

Developing
ICON Data Assimilation
and
Ensemble Data Assimilation

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Setup: Model & DA Timeline

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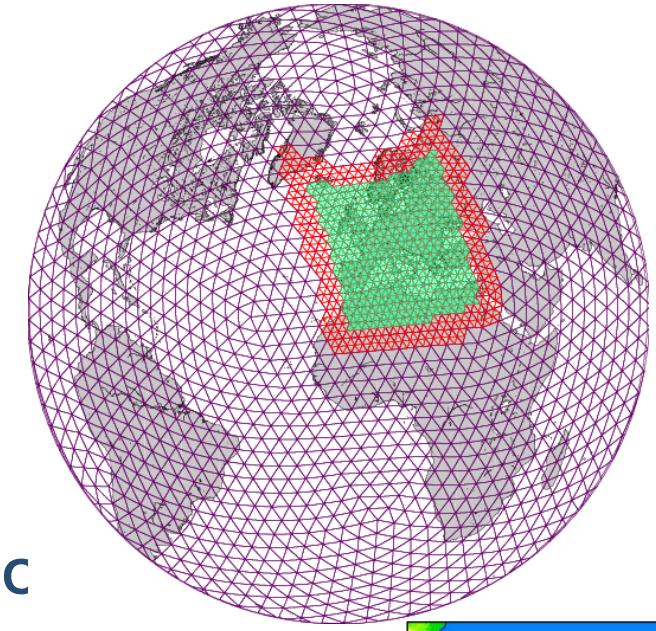
2014

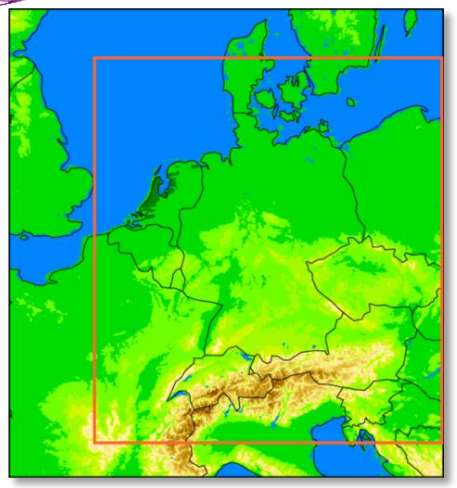
(1) Global Model **GME/ICON**
1st Step: **ICON** replaces GME



2015

(2) VarEnKF replaces 3dVAR

(3) Refined Region over Europe
2nd step: **ICON** replaces **COSMO**



(4) KENDA replaces Nudging for Cosmo-DE

(5) High-Resolution Model **COSMO-DE**
(central Europe)
3rd step: **ICON** replaces COSMO-DE

2020

Ensemble-DA Hierarchy

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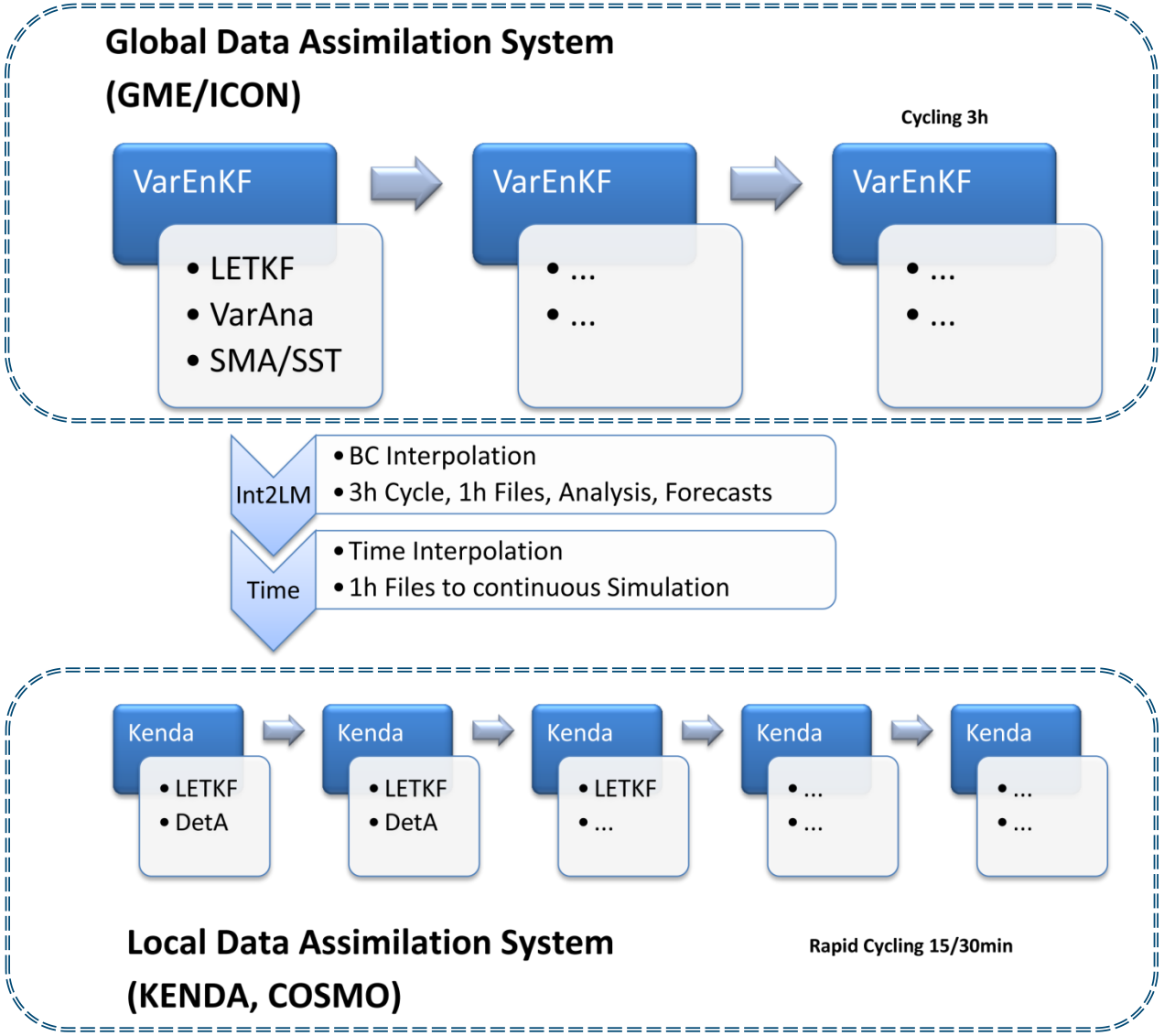

Publications in Progress:

Perianez, Reich and Potthast: Error Analysis and Adaptive Localization for Ensemble Methods in Data Assimilation, *submitted*

Perianez, Reich and Potthast: „Multistep-Analysis for Ensemble Methods in Data Assimilation“, *to be submitted*

Rhodin, Reich and Potthast: „A Hybrid Variational-Ensemble-Kalman-Filter, Methodology and Simple Tests“ , *in Preparation*

Rhodin, Reich, Ambadan and Potthast: „The DWD VarEnKF Global Data Assimilation System“, *In Preparation*

VarEnKF Migration

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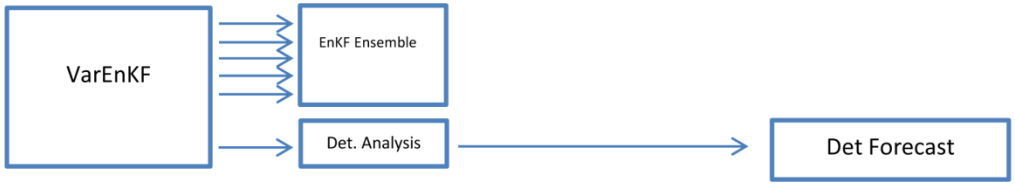
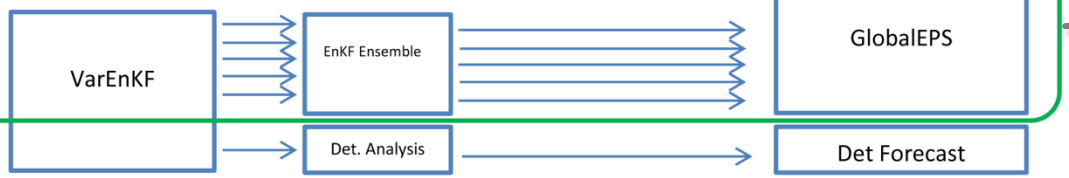
Current State

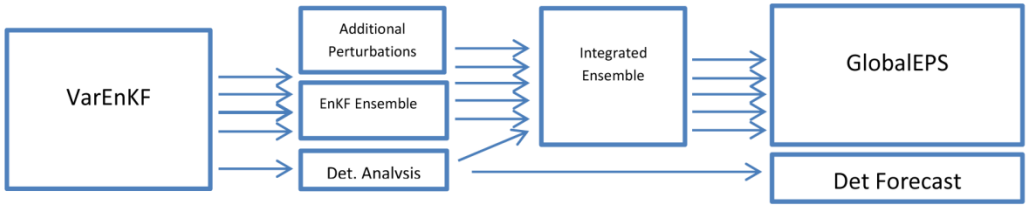
Level 1

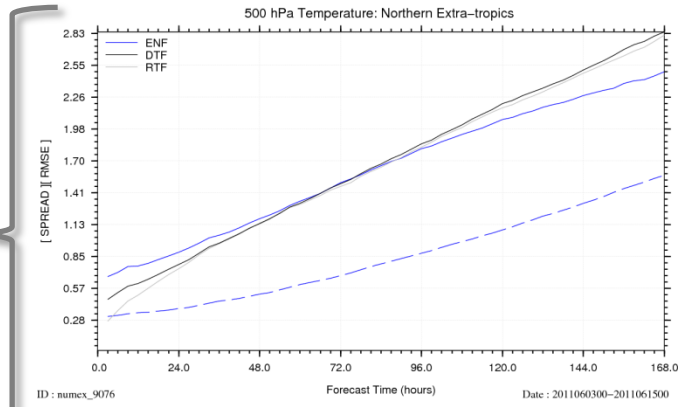


Level 2



Level 3





KENDA Migration

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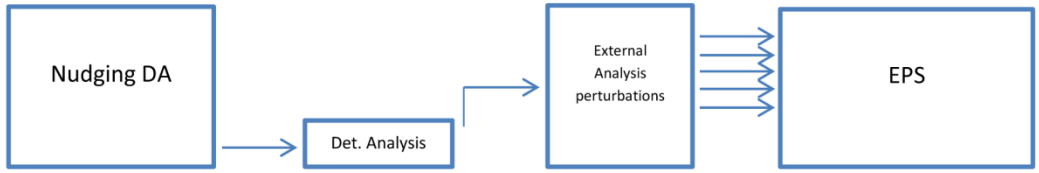
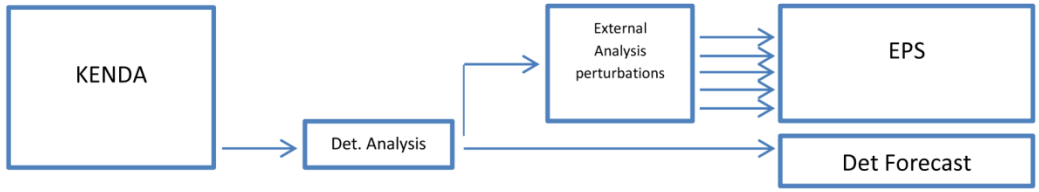
Current State

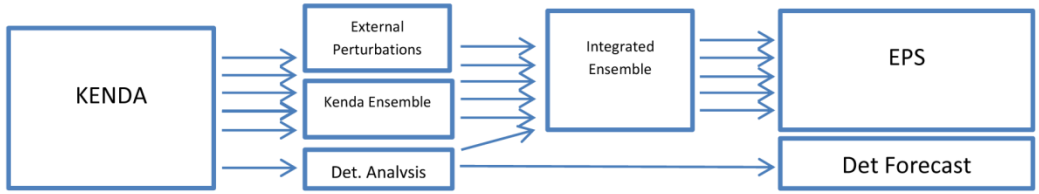


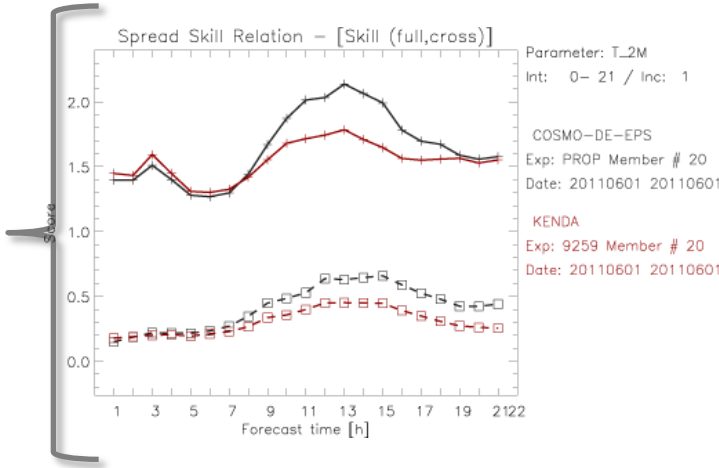
Level 1



Level 2

Level 3





Survey I: Main Parts

1. **Global EnKF** for GME in NUMEX (experimental system),
   State: calibration phase in progress

2. **Hybrid System Det-A** (high-resolution deterministic analysis),
   VarEnKF Hybrid System (variational analysis)
   State: implementation in progress

3. **Int2LM**: Interpolation of Boundary Conditions to Regional Resolution, *State: working*

4. **EnKF + DetA (KENDA)** for Regional System, HErZ + in NUMEX
   State: calibration phase in progress

Data Assimilation Survey II

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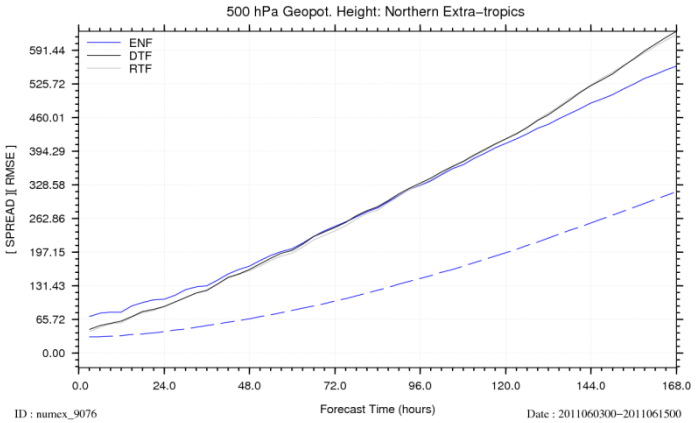
Global EnKF for GME in NUMEX (experimental system), *calibration phase in progress*



1. Full System with all current observation systems *running*
2. Currently: verification against own analysis **comparable** with current 3dVar system
3. Work in progress on **spread** in different regions (upper troposphere, Europe, …)
4. Adaptive localization **calibration** is ongoing
5. Technical work on more efficient ensemble verification ongoing
6. **Archive/Storage** Challenges remain severe
7. Scientific understanding of **localization**: publication submitted
8. **Multistep-Assimilation**/Successive Assimilation: implementation ongoing

Publications in Progress:

- Multistep-Assimilation: basic mathematics paper being finished
- Multistep-Assimilation: meteorological paper in preparation

Data Assimilation Survey III

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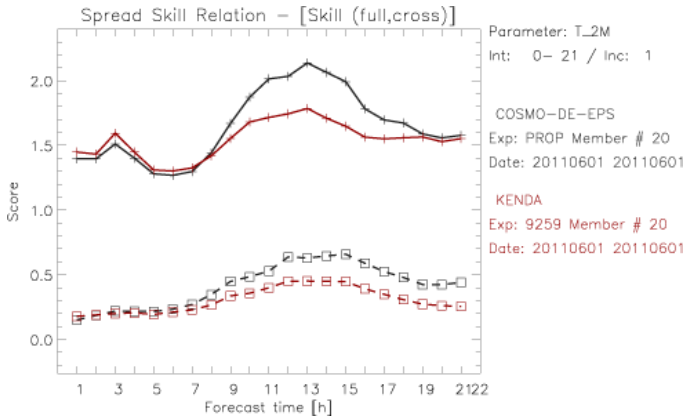
KENDA for COSMO-DE in NUMEX (experimental system), *calibration phase in progress*



1. Full System with **conventional data** *running*
2. Work on **Radar Operator** and Latent Heat Nudging, implementation done, tests in progress
3. Further **Observation Systems** under development (e.g. SEVIRI, GPS/GNSS, Lidar, …)
4. Currently: verification against observations
5. Work in progress on **spread** in different regions (upper troposphere, Europe, …)
6. Adaptive localization **calibration** is ongoing
7. Technical work on more efficient ensemble verification ongoing
8. **Archive/Storage** challenges remain severe
9. **Multistep-Assimilation**/Successive Assimilation: implementation finished

Publications in Progress:

- Retrieval Assimilation: basic mathematics paper being finished
- GNSS-Tomography: algorithmical issues in preparation

ICON DA Development I

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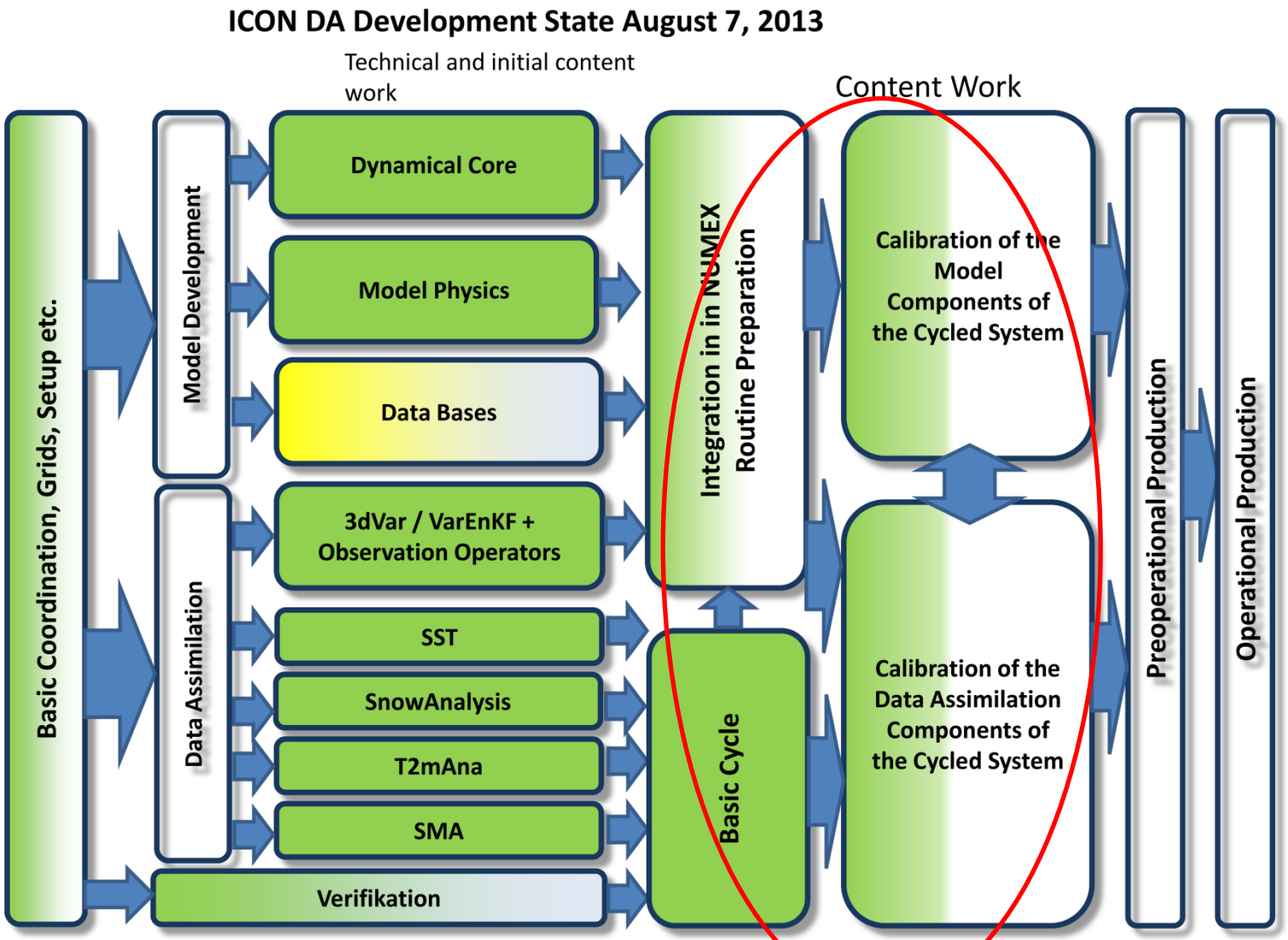

ICON DA Development II

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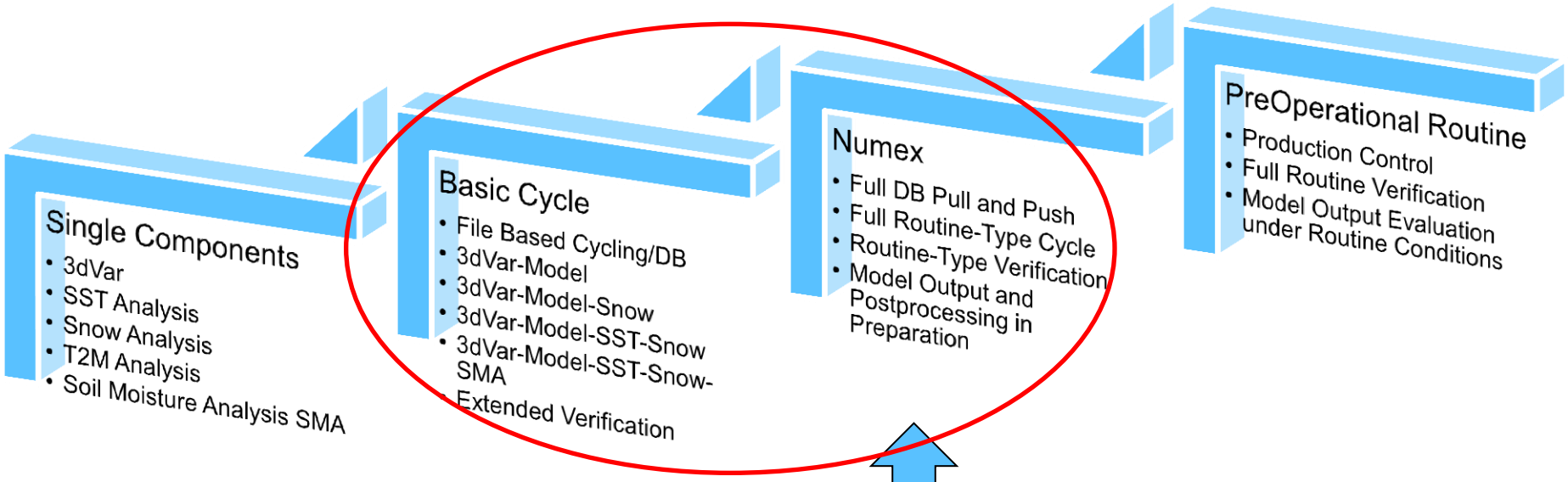

Basic Cycle (FE12):
- ***3dVar-Model working***
- ***3dVar-Model-SST working***
- ***3dVar-Model-SST-Snow working***
- ***SMA-3dVar-Model-SST-Snow working***

NUMEX (FE13)
work in progress

ICON DA Development III

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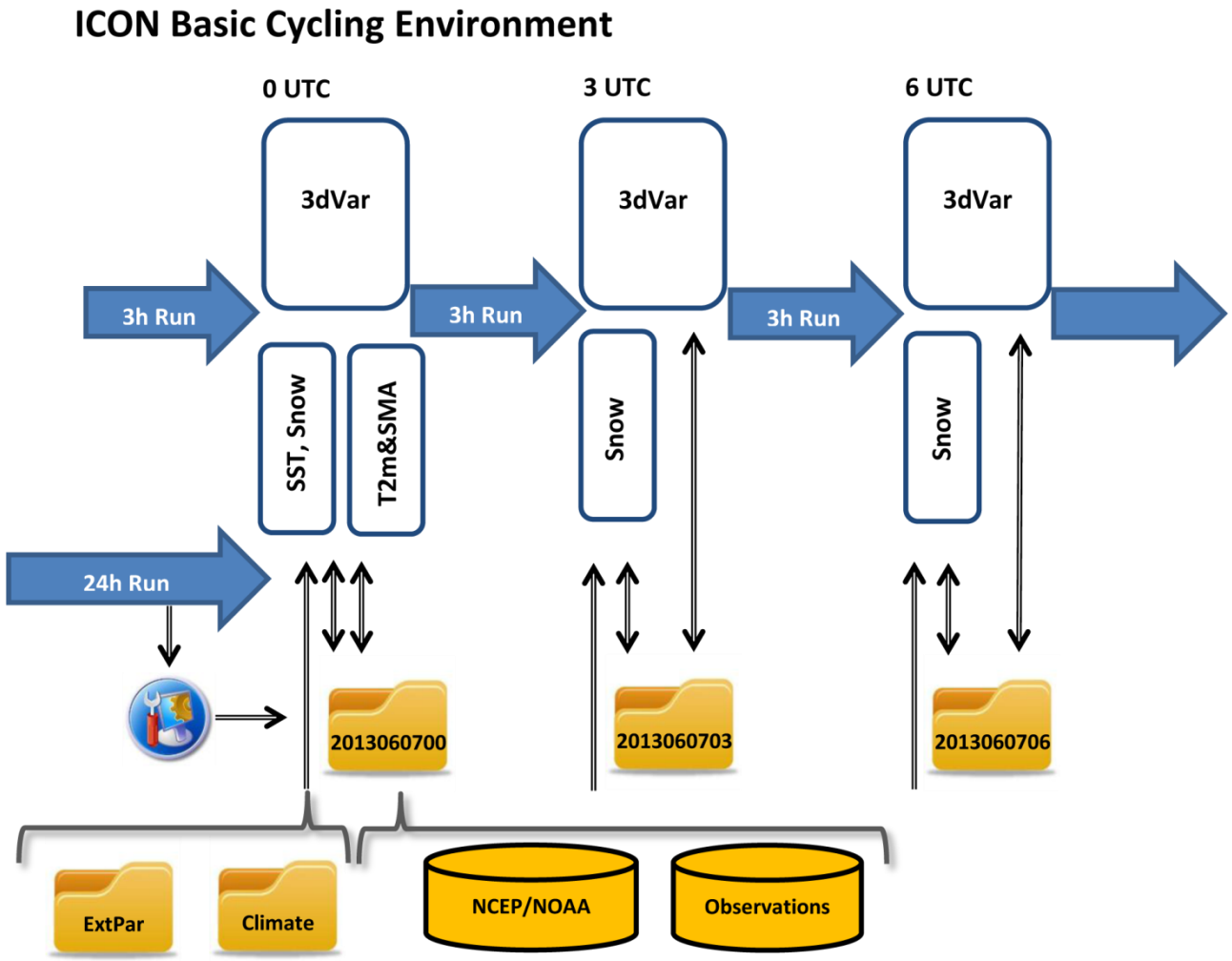
Basic Cycle

- Elementary Cycling; principle of simplicity
- File Based for Model Fields
- Flexible DB/Files for Observations
- Useful for Debugging
- Basic speed check for DA components
- Needed for efficient NUMEX implementation and test



ICON DA Development IV

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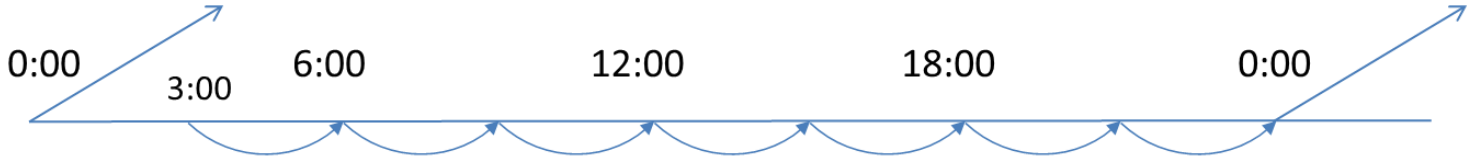
Forecast cycle

Analysis cycle

Ur-Start

1. Main run 24 hr fc,
Start from GME soil



GME soil and surface interpolated, SMI produced externally

3D-Var Snow

3D-Var Snow

3D-Var Snow

3D-Var Snow

3D-Var Snow

3D-Var Snow

3D-Var Snow

3D-Var Snow
SST
SMA(d+1)
(T2m(d))

Start of 3D-Var cycling, Initial fields from relabled 3hr output of 0:00 UTC main run

- GME surface is interpolated to ICON grid (SMI)
- Atmospheric fields are taken from IFS
- ICON starts with these fields as separate input
- Basic Cycling Model-3dVar can now take plase in the Basic Cycle
- Snow analysis takes 3h first guess as input
- a 24h model run generates the fields for the first SMA at 0UTC of the following day.
- SST at 0UTC of the followig day is started with input from the basic cycle

ICON Data Assimilation

1. **Components (3dVar, SST, Snow, T2M, SMA)** have been adapted

(except RO part)

2. **Basic Cycle**: 3dVar-Model-Cycling working

3. **Basic Cycle**: Surface Analysis Parts are working

4. **NUMEX** implementation to be done, work in progress by Thomas Hanish, FE13

5. Radio Occultations (**RO**) work ongoing

6. Satellite Data (**MW/IR**) and basic calibration is ongoing

7. **Archive/Storage** challenges remain severe

ICON DA Development VI

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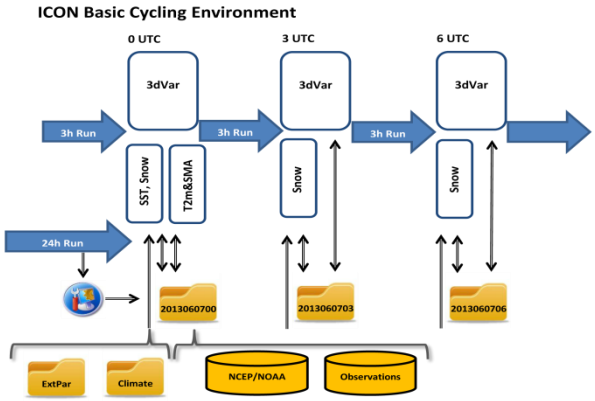
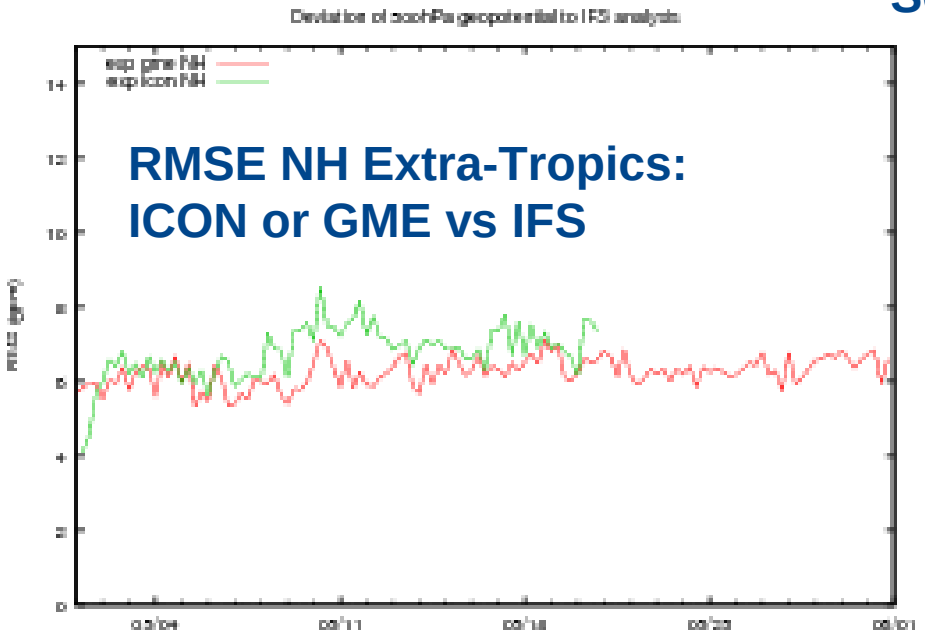
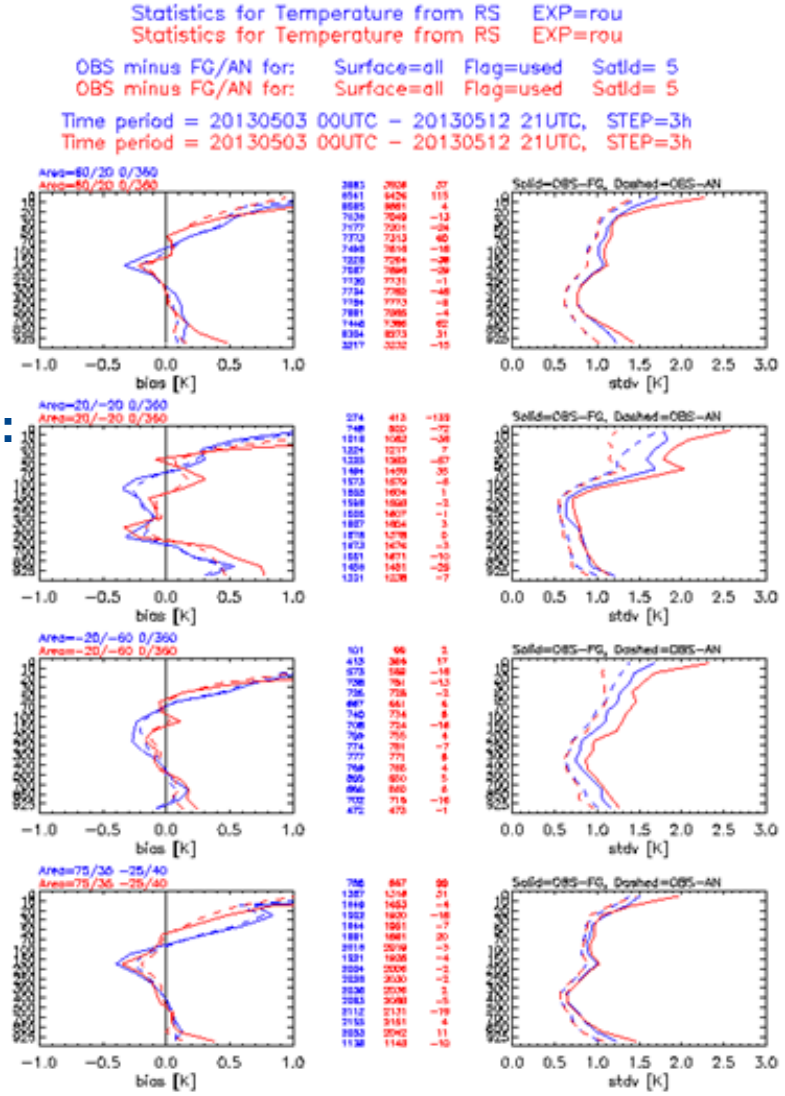


First tests, conventional observations only



Radio-Sondes:



ICON DA Development VII

I. Technical Cycling Tests
Model and 3dVar Cycling (b) Model and 3dVar and Surface Analysis full Cycling

II. Noise Behavior 3dVar-Model
We need to analyse the noise which is fed into the cycled system through assimilation.

III. Content Work, Initial Tests
Verification Technical Tests on atmospheric fields and surface fields (b) Comparison of low-resolution behavior with full-resoution behavior

IV. Assimilation Classical Data Only [plus Radio Occultations]
A 1-2 month test with classical data assimilation needs to be run at least 2 to 3 times (including calibration between the runs)

ICON DA Development VIII

V. Assimilation Surface Analysis

We need to run a longer period of at least 2-3 month at least two times to test the behavior of surface fields and possibly adapt calibration parameters.

VI. Passive Phase for Satellite Data

We need 4-8 month runs to monitor the bias of satellite instruments and analyse the behaviour of a model climate when classical data are used only.

VII. Assimilation Basic Data

Basic Data := Classical Data + RO + AMV + Scat

We need to run 2 month of cycling with basic data. Then we need calibration and a second 2month run with basic data.

VIII. Assimilation Basic Data + AMSU-A/ATMS

To include the assimilation of microwave sounders (AMSU-A/ATMS) we need to run 1-2 month, calibrate the assimilation and rerun the cycling over 1-2 month.

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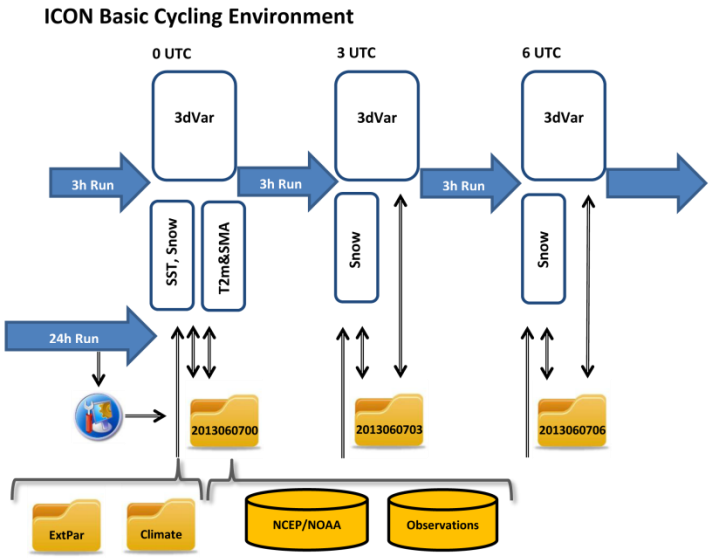
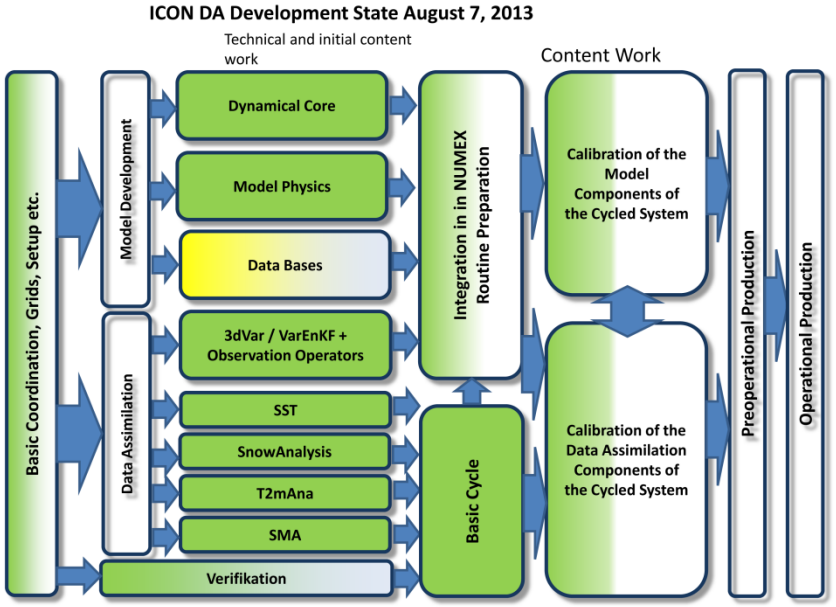
IX. Assimilation Basic Data + HIRS

To include the assimilation of infrared sounders (HIRS/IASI), we need to run 1-2 month, calibrate the assimilation and rerun the cycling over 1-2 month.

X. Assimilation Experiments with complete System

We need to run assimilation experiments with all data systems currently used in the routine system. It needs 2month runs at least two times, with a calibration phase in between.





Data Assimilation
Development Activities Part 1

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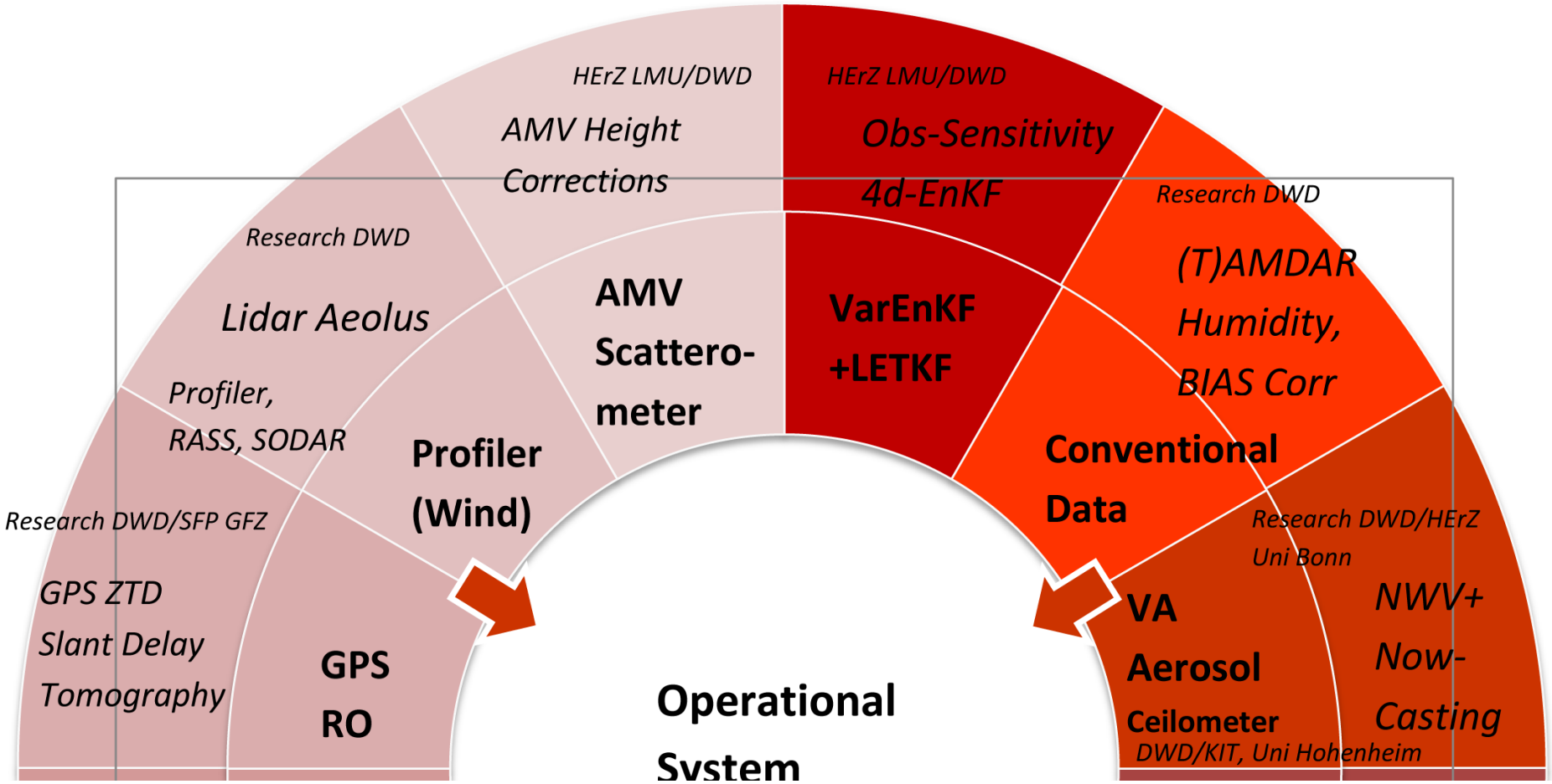

Data Assimilation
Development Activities Part 2

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