Surface skin temperature for satellite data assimilation at ECMWF

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ECMWF

Overview

- Introduction: The importance of skin temperature for satellite DA

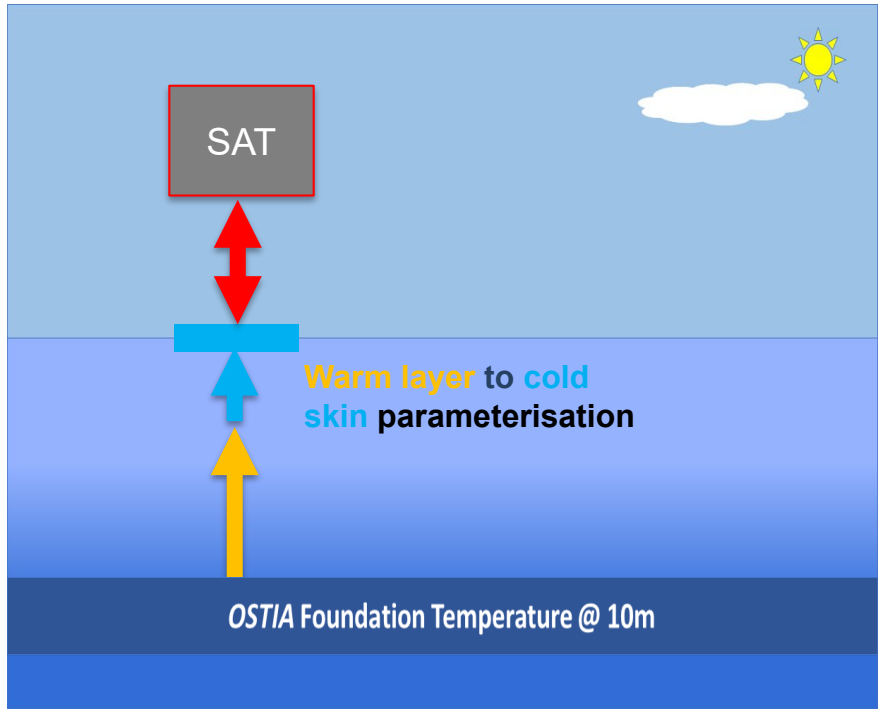
- 1D-ACV approach:
  - Adjustment of SKT during the 4D-Var analysis;
  - New background error formulation for SKT adjustment;

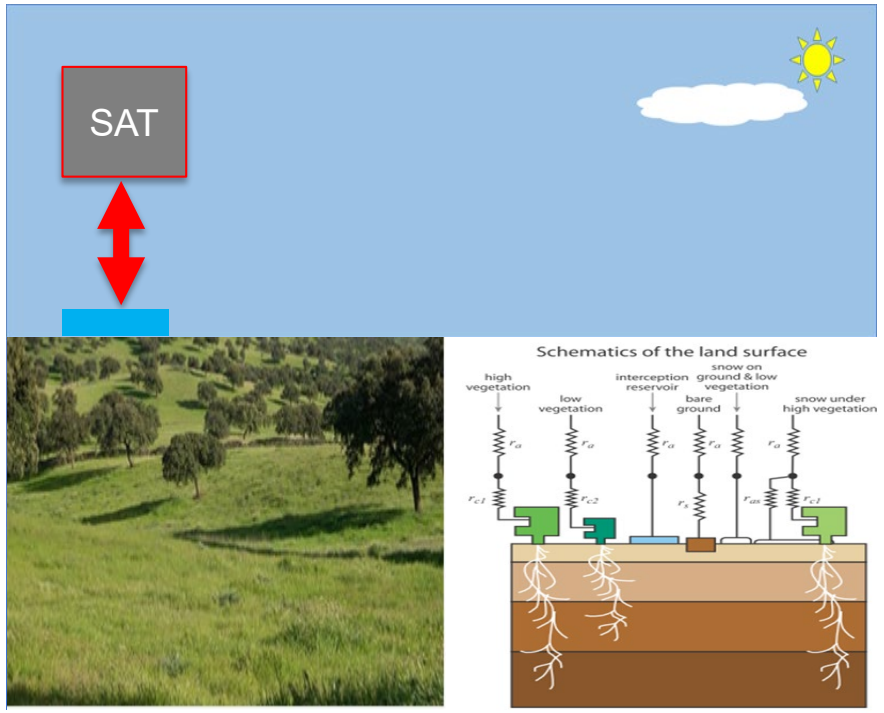
- Assimilation experiments results

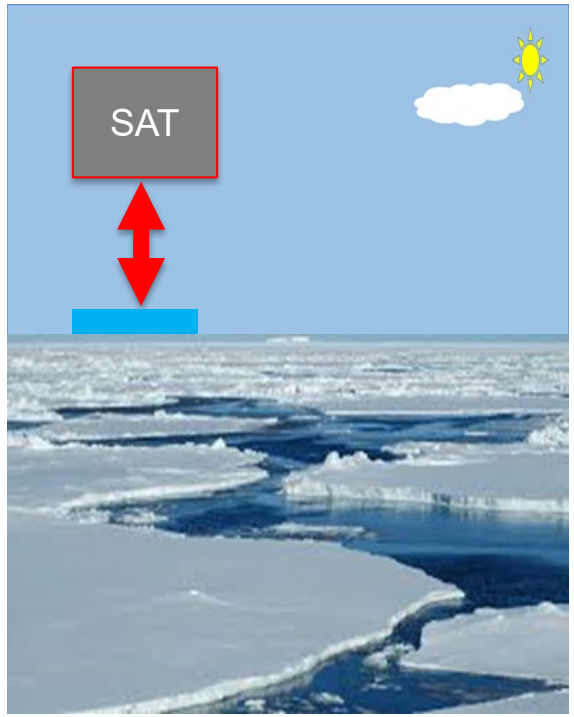
- Summary and future perspective

The importance of skin temperature for satellite DA

- IR and MW radiance observations sensitive to the mid and lower troposphere typically contain a contribution of radiation emitted from the underlying surface;
  - To extract the atmospheric information from these observations we need an accurate estimate of surface emission and an accurate estimate of skin temperature (SKT).

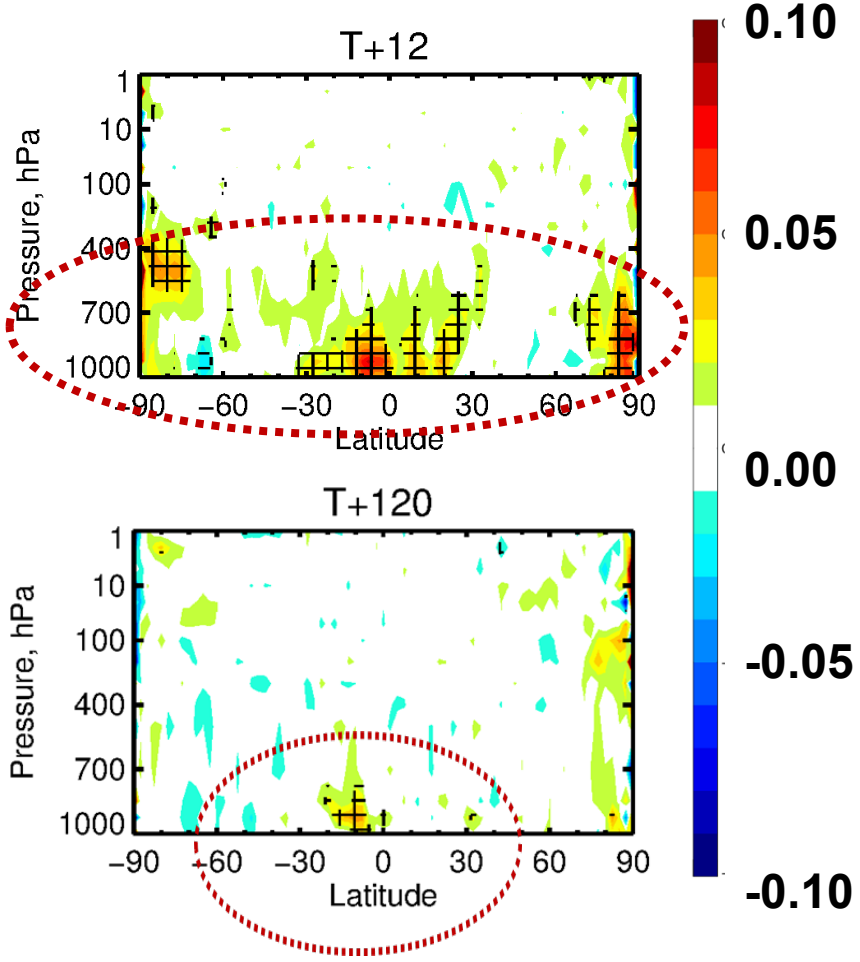






Use the ECMWF model SKT for satellite DA – as fixed input

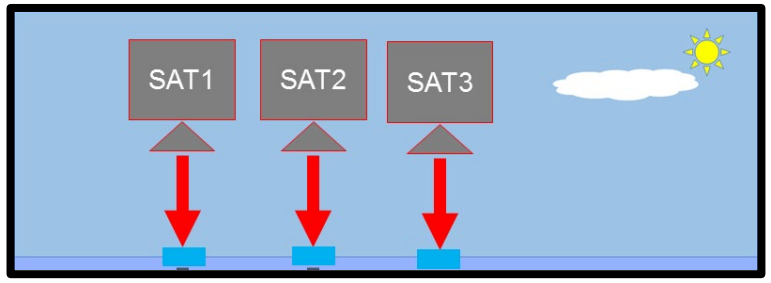
Change in std. dev. error of temperature when model SKT is used for radiance DA as fixed input.



- Errors in the SKT are being aliased into spurious analysis increments!
  - At T+12, the increase in the standard deviation errors in temperature observed in the lower atmospheric layers is a reflection of larger temperature increments.
  - Degradations in the Tropics between 1000-850 hPa persist at day 5 forecast range.

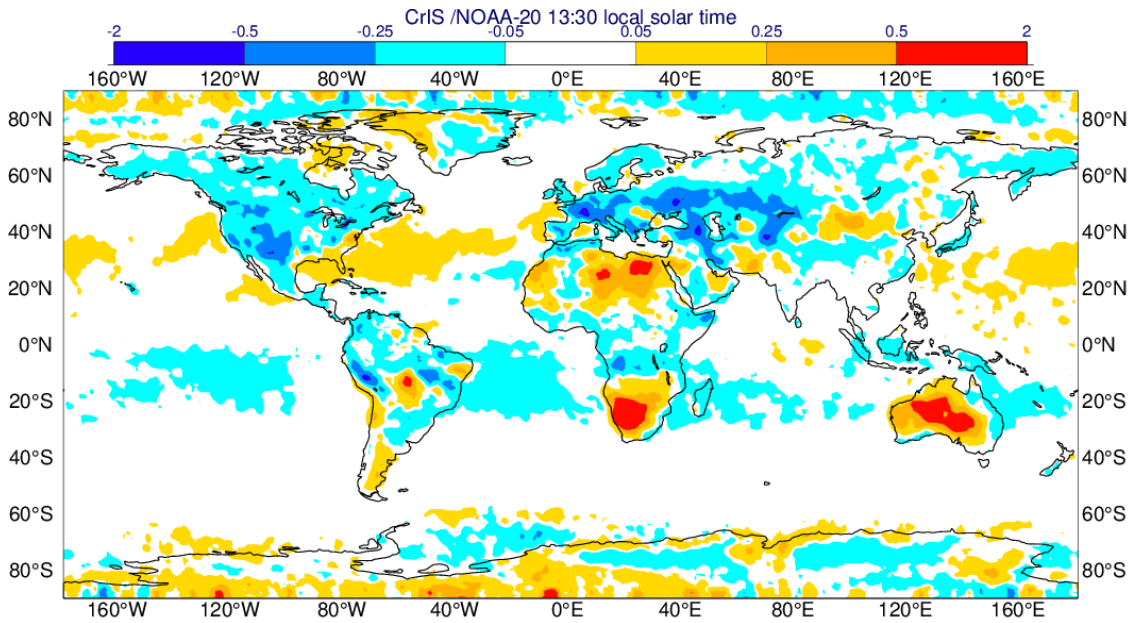
Current 1D-ACV approach (or local sink-variable approach)

- SKT must be allowed to adjust simultaneously with the atmospheric variables during the 4D-Var minimization;



- Each satellite radiance observation produces a point SKT increment at the time and location it was measured.

Mean adjustement of the 1D-ACV forced by IR radiance obs. from the NOAA-20 CrIS instrument (July 2019)

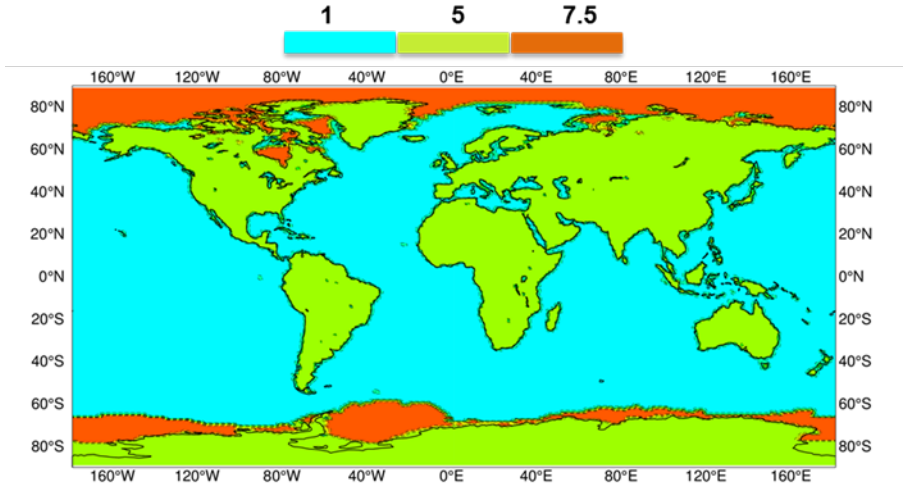


- The SKT increment is discarded at the end of the 4D-Var minimization (does not affect the subsequent forecast or the next analysis).
- It is not coupled to any of the atmospheric variables in the background error covariance and uncoupled from the SKT at other locations.
- The magnitude of the SKT adjustement is controlled by a background error term

Background error formulation for SKT adjustment

Current system:

- SKT background error term is set to a globally constant value of: 1K (ocean), 5K (land) and 7.5K (sea-ice);

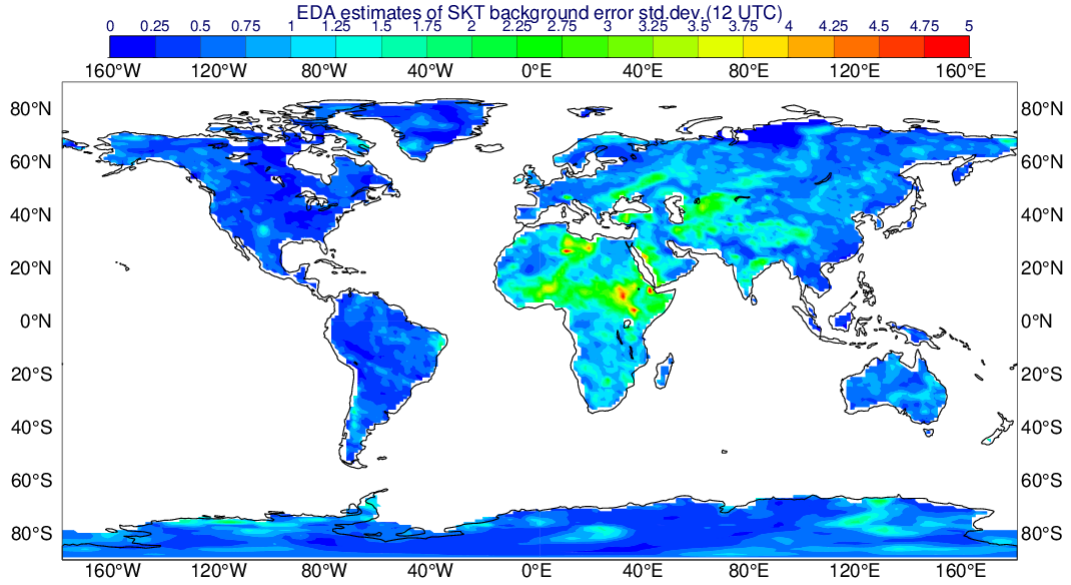


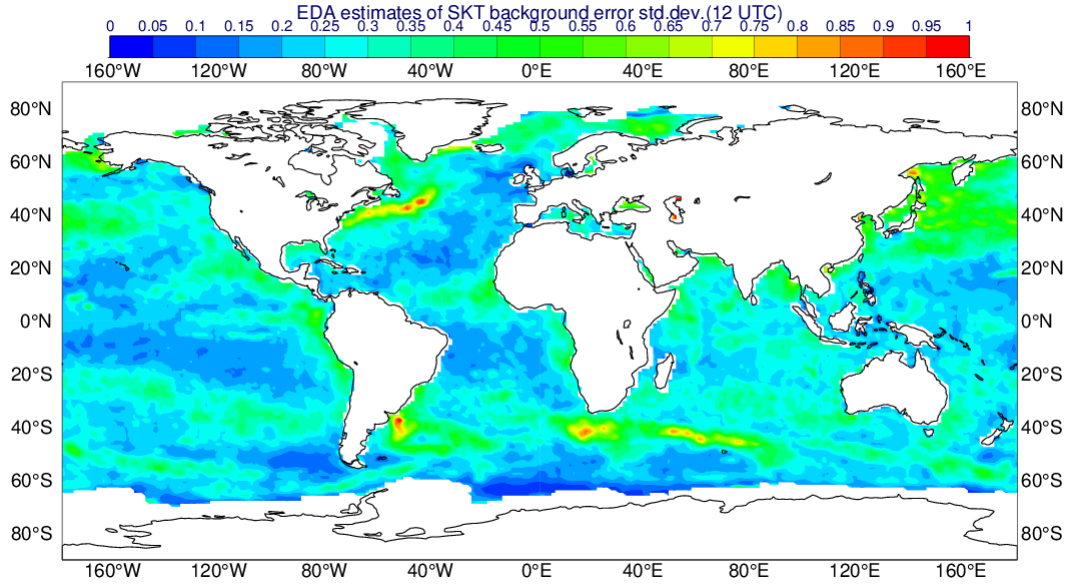
Proposed new system:

- SKT background error term is based upon output from the ECMWF EDA (e.g., 50-members EDA spread generates flow dependent SKT background errors which vary spatially and in time during the 12-h assimilation window.

EDA-derived SKT background errors: output from the OPS EDA

1st June 2019, 12 UTC





- Spatially and time (every 1-h) varying background errors for SKT;
- Different surfaces are intrinsically more uncertain than others, but this uncertainty can also be strongly dependent on the time of day;
  - Land surfaces - errors can change rapidly during the day, synoptically or seasonally;
  - Ocean - EDA-based SKT errors might capture different uncertainty in model SKT between daytime low wind and nigh time high-wind situations;
  - Sea-ice and open water - small EDA spread, close to zero

Communicate the appropriate SKT errors **over land** to LEO/GEO inst.

LEO satellites seeing different land surfaces / the same land surfaces at different times of day may be exposed to different SKT errors.

LEO IR sensors:

Hyper-spectral:

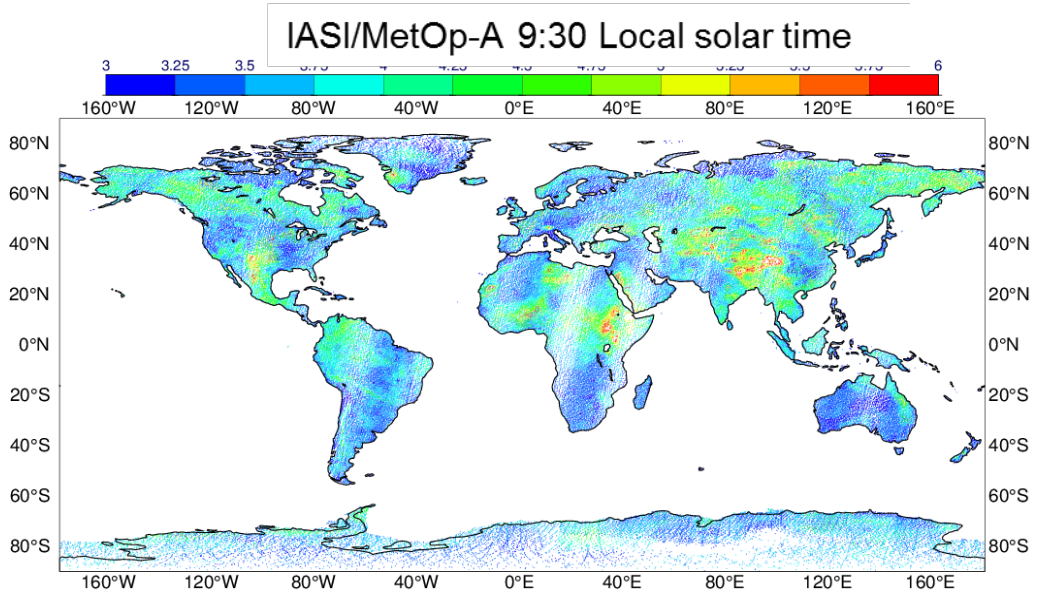
- **IASI**
- **AIRS**
- **CrIS**

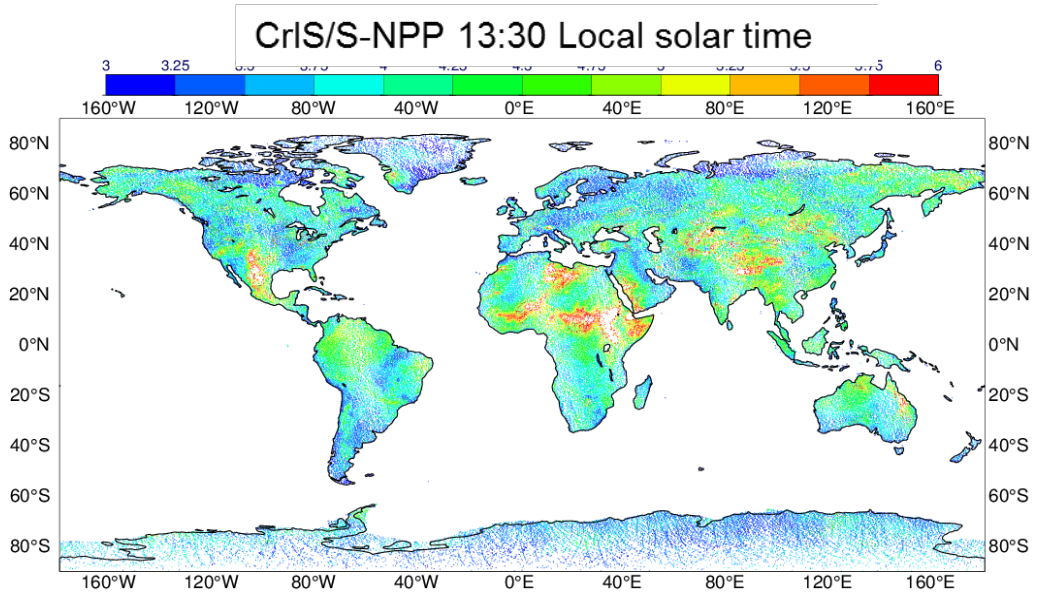
LEO MW sensors:

Cross track:

- **AMSU-A**
- **ATMS**
- **MWH/TS**

Satellite	LTAN / LTDN
NOAA-15	19:00 / 7:00
NOAA-18	21:00 / 9:00
NOAA-19	17:00 / 5:00
NOAA-20	13:30 / 1:30
Aqua	13:30 / 1:30
S-NPP	13:30 / 1:30
MetOp-A	21:00 / 9:00
MetOp-A	21:30 / 9:30
MetOp-C	21:30 / 9:30
FY-3B	16:00 / 4:00





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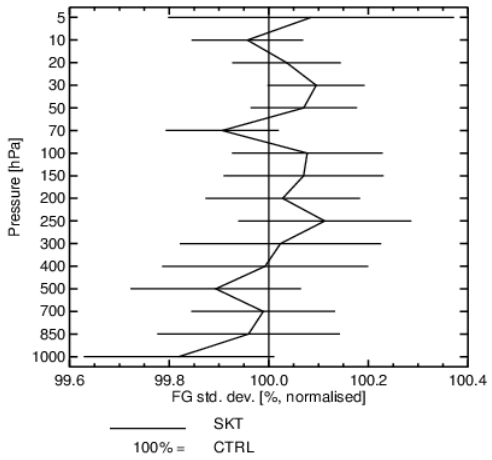
EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FOR

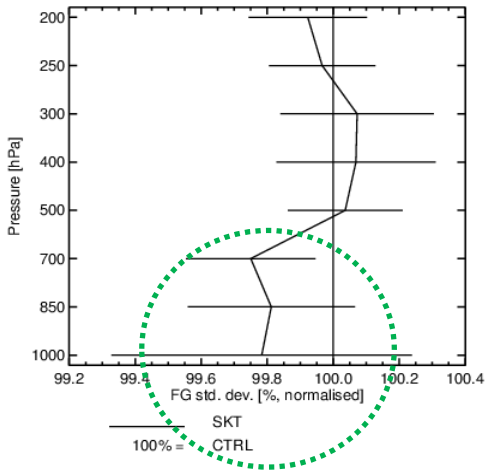
Impact in assimilation experiments

Stdev(o-b), normalised by Control, global, March –June 2019

TEMP-T

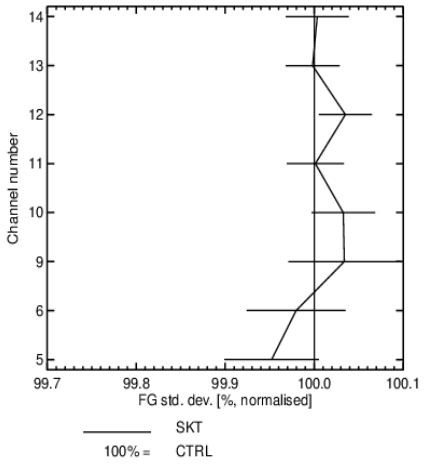


AIREP-T

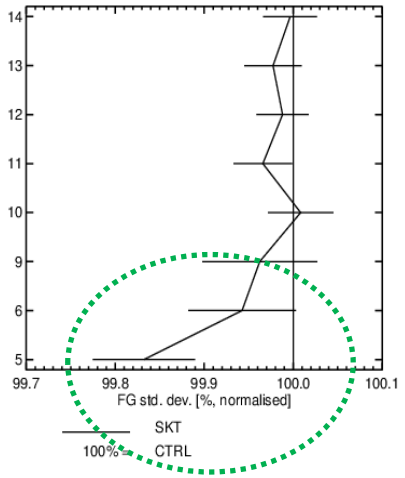


- Small improvements are seen in short-range forecasts temperature (e.g., TEMP-T and AIREP-T obstat fit in the lower troposphere);

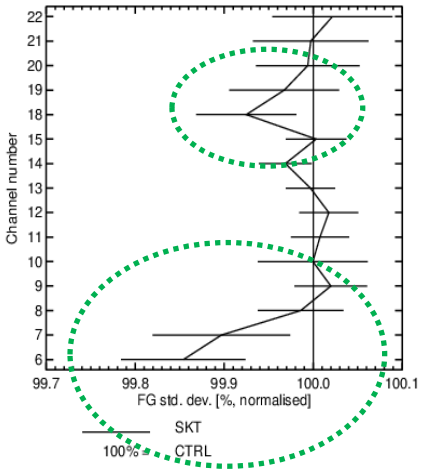
AMSU-A MetOp-A



AMSU-A NOAA-19



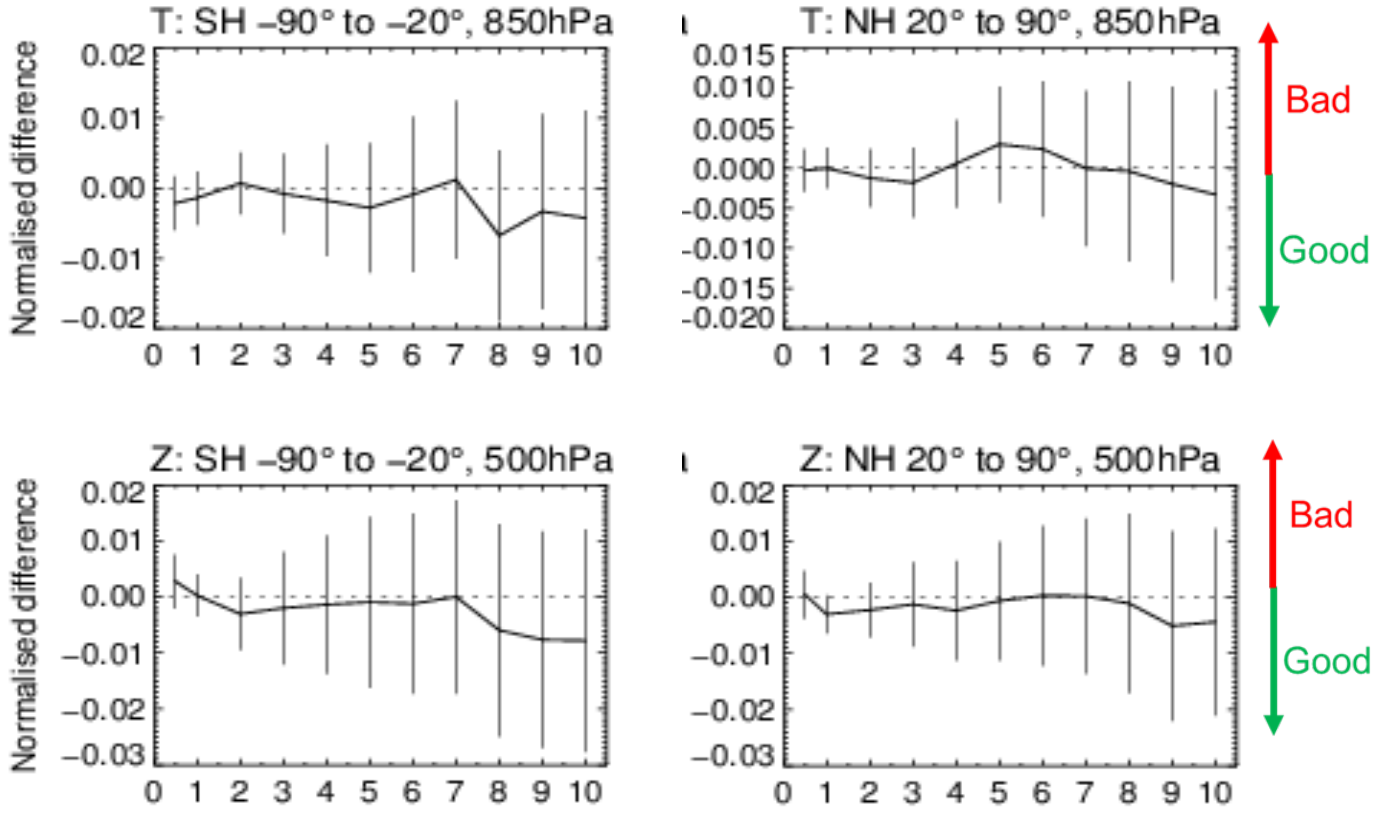
ATMS S-NPP & NOAA-20



- Better background-equivalents for sounding observations

Forecast verification

Normalised difference in std. dev of forecast error
T 850hPa (top) and Z 500hPa (bottom)



Verified against own analysis

- Neutral impact in medium-range headline scores (e.g., Z500 hPa, T850 hPa)

Summary and perspective

- A poor estimate of SKT quickly aliases into spurious upper air atmospheric increments and this will be seen when resulting analyses and forecasts are verified;

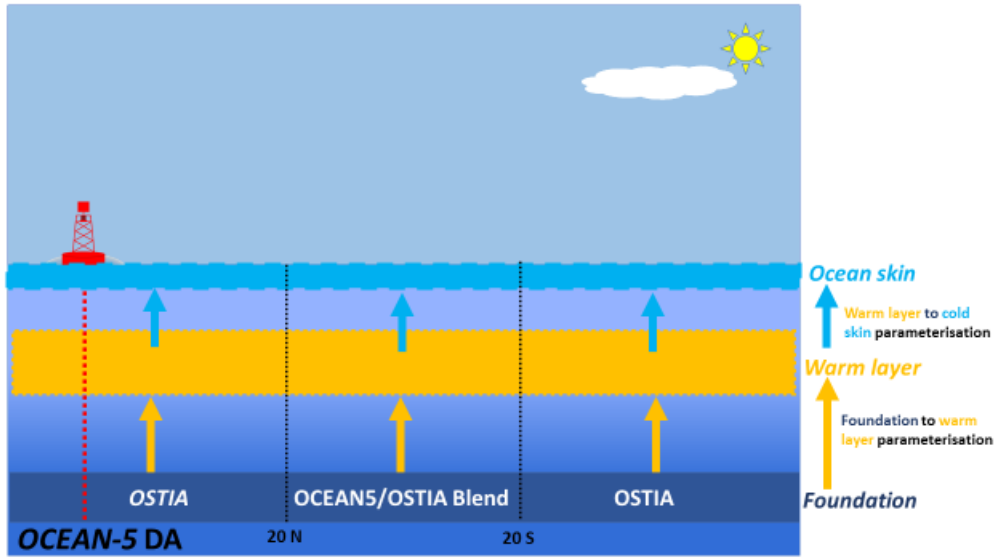
- The existing 1D-ACV produce an analysis of SKT at each observation location → there is a signal in radiance observations that could be used to produce an explicit analysis of surface skin temperature;
  - Extend the 4D-Var to estimate SKT … a first step in the development of an in-house SST

- SKT backgrounds errors remains important to a successful separation of surface and atmospheric signals contained in the radiance observations & to assimilation of satellite radiance observations in 4D-Var;
  - Spatially and time varying EDA-based SKT background errors have been derived and tested; This functionality is now included in cy47r1 for operational implementation (50 members EDA and 4D-Var, over land only);
  - Better agreement with conventional observations, neutral impacts on forecast scores.

Strong science case for ECMWF to develop our own in-house SST

Current system:

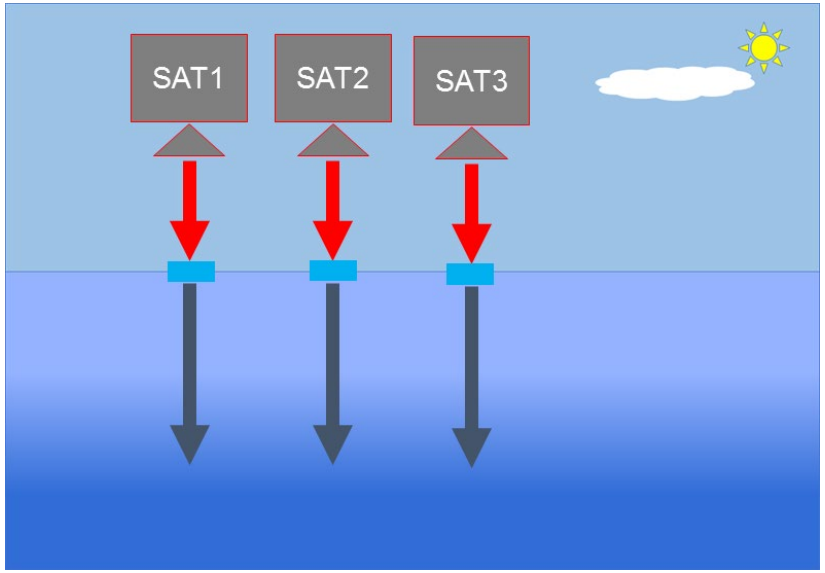
OCEAN-5 SST constrained by OSTIA from below



Satellite information introduced to OCEAN-5 via OSTIA…

Proposed future system:

OCEAN-5 SST constrained by 4D-Var SKT from above



Satellite information introduced to OCEAN-5 via 4D-Var…