Probabilistic evaluation of decadal predictions using a satellite simulator for SSM/I and SSMIS

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Overview: *A satellite simulator for SSM/I (Special Sensor Microwave Imager) and SSMIS (Special Sensor Microwave Imager and Sounder) is developed and applied to the MiKlip-II pre-operational decadal prediction system (https://www.fona-miklip.de/). The aim is to evaluate the decadal prediction skill focusing on different components of the global hydrological cycle. On the reference side the SSM/I & SSMIS Fundamental Climate Data Record (FCDR) provided by the CM SAF (DOI: 10.5676/EUM_SAF_CM/FCDR_MWI/V003), publicly available via the web user interface http://wui.cmsaf.eu, is used. The FCDR covers the period from 1978 to 2015. Results are shown for selected channels which are sensitive to water vapor and precipitation.*

85 GHz (p_v-p_h), 1988-2006

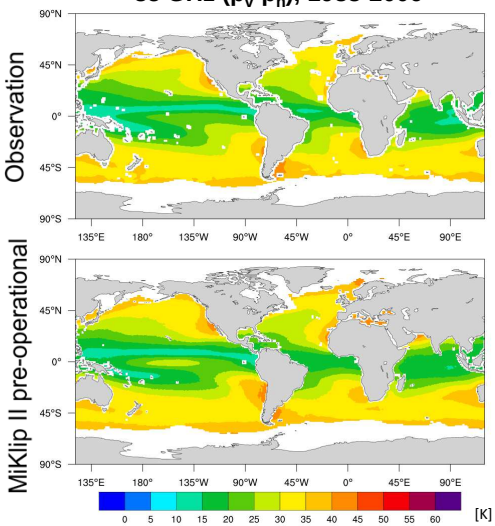

Figure 1: *Brightness temperature multi-year averages (1988-2006) of SSM/I and SSMIS for the 85 GHz vertical minus horizontal polarization channel for (top) observations and (bottom) COSP SSM/I & SSMIS simulator applied to MiKlip II pre-operational system (lead year 1). Land areas are masked out due to lack of surface information.*

- The satellite simulator is used to deduce radiances from climate model data for the different spectral channels which are covered by the satellite based instrument. Therefore, the evaluation is performed in the instrument's parameter space which reduces uncertainties on the side of the observations.
- The satellite simulator for SSM/I and SSMIS is developed utilizing the CFMIP Observational Simulator Package (COSP)[1,2].
- Brightness temperature of the 22 GHz channel (vertical polarization) is sensitive to the water vapor content.
- The difference of the 85 GHz vertical minus horizontal polarization channels is sensitive to the hydrometeor content.
- Results obtained for the COSP SSM/I & SSMIS satellite simulator applied to the MiKlip II pre-operational system resemble the general structure and amplitude of the observations for multi-year time averages (example shown in Fig. 1 for 85 GHz channel).
- Over the central equatorial Pacific there is evidence for a double ITCZ structure (Fig. 1, bottom) which is a common feature of GCMs.

[1]*Bodas-Salcedo et al., 2011: COSP: Satellite simulation software for model assessment. Bull. Amer. Meteor. Soc., 92, 1023–1043, https://doi.org/10.1175/2011BAMS2856.1*

[2]*https://www.earthsystemcog.org/projects/cfmip/cosp*

22 GHz, 1988-2012, #=4 | **22 GHz, 1988-2008, #=7**

85 GHz (p_v-p_h), 1988-2012, #=4 | **Precip, 1988-2012, #=4**

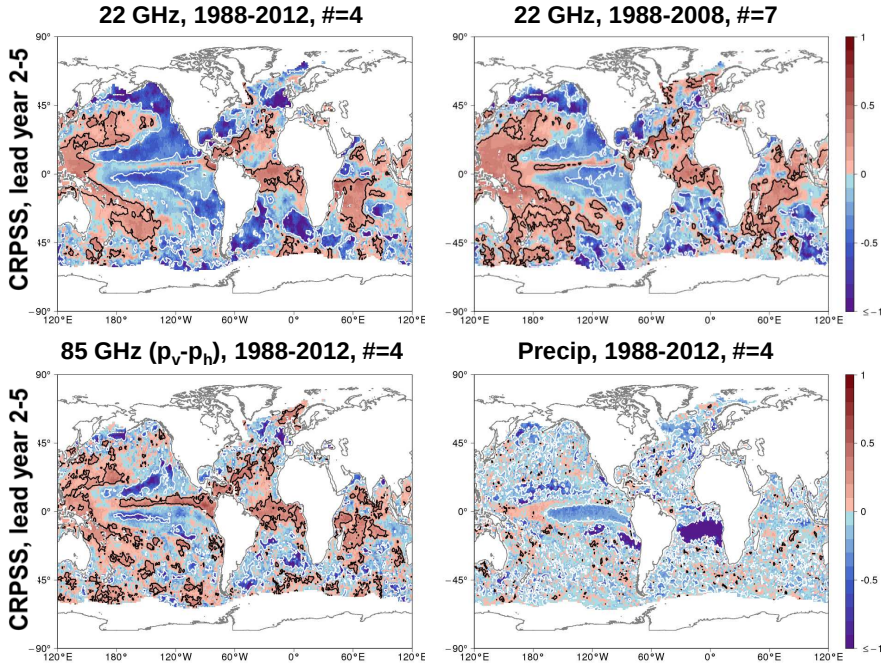

Figure 2: *MiKlip II pre-operational system forecast evaluation of lead year 2-5: CRPSS of brightness temperature for the (top) 22 GHz channel and for the (bottom left) 85 GHz vertical minus horizontal polarization channel. Land areas are masked out due to lack of surface information. CRPSS for precipitation utilizing HOAPS-4 (doi: 10.5676/EUM_SAF_CM/HOAPS/V002) as observational reference is additionally shown (bottom right). 4 realizations with CMIP5 forcings are used. Additionally, results with 7 realizations (3 realizations with CMIP6 forcings) are shown for the 22 GHz channel (top right).*

For lead years 2-5 the Conditional Ranked Probability Skill Score (CRPSS) indicates predictive skill for large parts of the tropical/sub-tropical ocean areas (Fig. 2). For the 22 GHz channel hindcasts are mainly outperformed by climatology in the eastern Pacific (Fig. 2 top left, top right). Consistent areas of predictive skill are found for a classical evaluation approach focusing on water vapor (not shown). By contrast, the 85 GHz channel shows predictive skill even for the ITCZ region in the Pacific (Fig. 2 bottom left). Less predictive skill is found when comparing precipitation against satellite retrieved precipitation estimates (Fig. 2 bottom right). The reason is that the measured brightness temperatures at 85 GHz are an integral measure which is sensitive to factors such as precipitation type, cloud hydrometeors and surface emissions. The question needs to be answered which of these parameters contribute to the predictive skill.

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