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Cloud cover retrieval using WRF meteorological model

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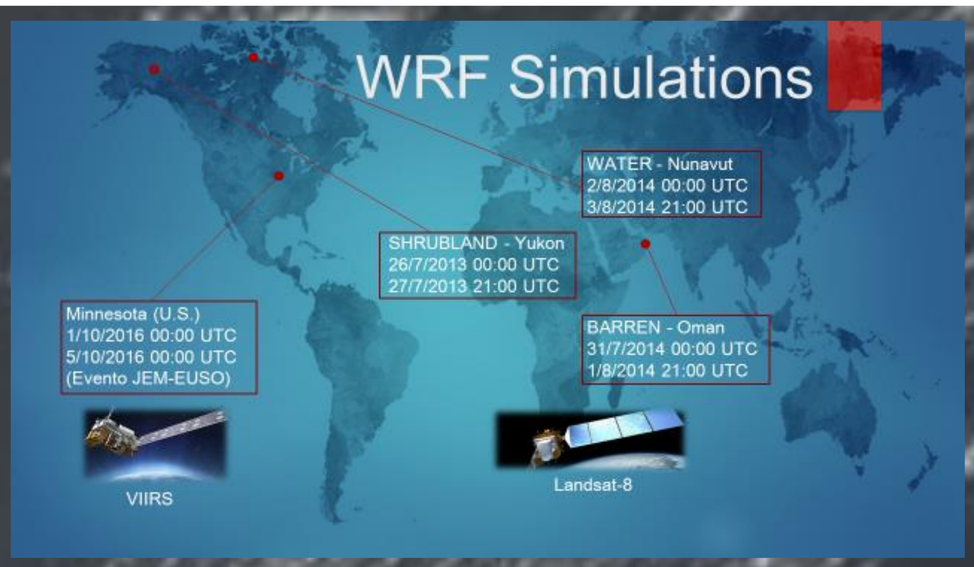
The presence and the amount of clouds over a specific area are one of the main meteorological features that are useful to determine in performing weather analysis and forecasting. Usually they are retrieved by satellite measurements.
A method based on Numerical Weather Prediction (NWP) models is here proposed; it allows a cloud coverage estimation also over areas not covered by satellite flights. The cloud cover is derived using the Weather Research and Forecasting (WRF) Model, attending two different methods:

1) Using a model output field, the **cloud fraction**
2) Computing an indirect quantity, the **optical depth**

A top-bottom directed algorithm is used to identify, for each grid point, at which level these two quantities overcome **a fixed threshold**, determining a cloud presence. In particular, the application of this algorithm is repeated several times using different threshold values and varying them with the altitude and the type of cloud, in order to verify in that way these parameters influence the reliability of the model in the retrieval of cloud coverage.
The estimates of the cloud cover are compared with two different **satellite measurements** to validate the results, in particular **VIIRS** and **Landsat 8** satellites.
VIIRS data contain a cloud mask evaluation generated by a specific algorithm, starting from radiative recordings; Landsat 8, instead, provides a database of manually generated cloud masks for various periods and types of regions.

In order to make a validation of the WRF based method, four different scenes were selected, characterized by non-homogeneous cloud coverage



Evaluation of cloud mask

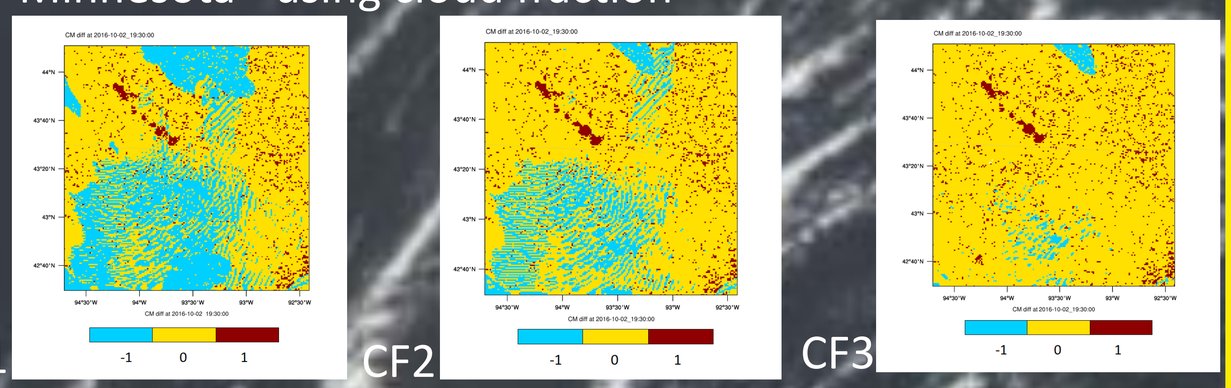
Cloud fraction threshold for high, middle and low clouds
CF1: 0.2, 0.2, 0.2 ; CF2: 0.4, 0.4, 0.6 ; CF3: 0.6, 0.6, 0.8

$$COD = (0.145 \times Qc + 0.272 \times Qi) \times \frac{\Delta P}{g}$$

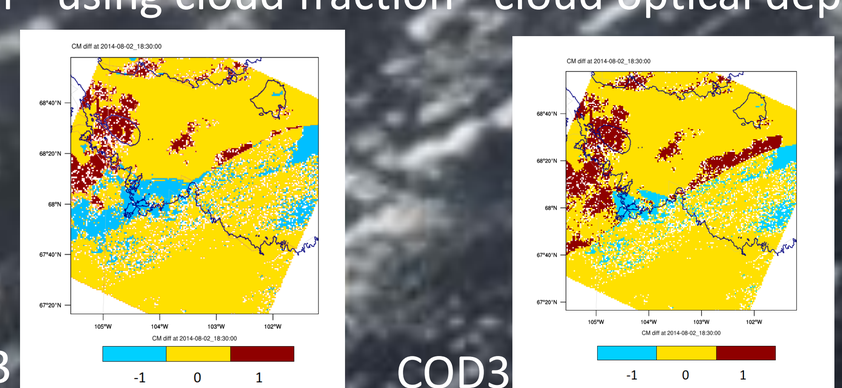
Cloud opthical depth threshold:
COD1: 0.002 COD2: 0.01 COD3: 0.1

Difference = Cloud mask satellite - Cloud mask WRF

Minnesota - using cloud fraction



Water –using cloud fraction - cloud optical depth



The comparison between simulations and satellite observations is performed computig the contigency tables and the accuracy

		WRF: Predicted YES	WRF: Predicted NO
SAT	Observed YES	TP	FN
	Observed NO	FP	TN

$$ACC = \frac{TP + TN}{TP + TN + FP + FN} \cdot 100$$

Minnesota case study	CF1	CF2	CF3	OD1	OD2	OD3
18:06 1/10	76%	65%	57%	55%	55%	55%
19:48 1/10	84%	81%	76%	69%	69%	69%
17:48 2/10	67%	81%	85%	89%	89%	89%
19:30 2/10	62%	84%	90%	92%	92%	92%
19:12 3/10	23%	44%	63%	74%	74%	74%

Case study	CF1	CF2	CF3	OD1	OD2	OD3
Water	78%	80%	80%	80%	80%	80%
Shrubland	43%	42%	43%	40%	40%	40%
Barren	63%	58%	58%	62%	59%	53%