## Response to reviewer 3 - detailed response

This supplement gives detailed answers to all comments of reviewer 3. The original comments are quoted in italic.

***Detailed comments***

*"One example of an imprecise sentence occurs in the abstract: “The solutions of the resulting water balance equations correspond to two different moisture regimes along a stream line, either monotonically increasing or monotonically decreasing when travelling inland,:” What exactly is increasing or decreasing? As it stands, “the moisture regimes” are increasing or decreasing. I do not think the authors are intending to say that the “the moisture regimes” are increasing or decreasing.*

**Answer**: The presented system of equations has solutions that correspond either to an increase of moisture along *x*, the spatial coordinate, or a decrease along *x*. The word "regime" is classically used in hydrology and meteorology to designate a set of temporal conditions (e.g. pluvial regime); here, we use the word in analogy for spatial conditions. This use is compatible with the use of "regime" in other disciplines, e.g. ecology, where it designates stable states of a system. From our point of view the above wording is neither misleading nor grammatically wrong but we are happy to change to: "(..) correspond to two different spatial moisture regimes showing either an increasing or a decreasing atmospheric moisture content along a stream line starting at the coast."

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*Another imprecise statement occurs on page 8319, line 5: “This approach presents analytical advantages since Langrangean trajectories, which can be obtained from data (e.g: : :..), contain considerably more information than what we would have in a purely Eulerian description using only velocity fields”. This sentence does not make sense to me! What kind of data are you referring to? Do you mean observational data or do you mean model data? How are Lagrangian trajectories determined if they are not determined with information about the velocity field?*

**Answer**: Thanks for pointing out that the statement was misleading. In general, the identification of trajectories is indeed mainly based on velocity fields (but could also take into account other information such as topography); this step of identification of trajectories corresponds to an extraction of information from observed data and does not "create" information. We will change the wording to: "This approach presents analytical advantages since Lagrangean trajectories, which can be obtained from observed velocity fields, represent a more condensed description of flow conditions than a Eulerian description of the point velocities”.

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*Then comes a choice, discussed beginning in Section 1.3 and throughout this essay, whether to observe and model the motion of moving fluid parcels, the Lagrangian approach that is closest in spirit to solid particle dynamics, or to model the fluid velocity as observed fixed points in space, the Eulerian approach. The essence of a Lagrangian representation is that we observe and seek to describe the position, pressure, and other properties of material volumes; the essence of an Eulerian representation is that we observe and seek to describe the fluid properties inside control volumes.*
*The term “Eulerian-Lagrangean” is used very frequently, but is unfortunately hardly very informative. For instance in the following sentence (p. 8318, line 10): “In this paper, we present a different type of analytical model: it describes the hydrological cycle at points along an atmospheric stream line (Eulerian-Langrangean approach) using only: etc. What is Eulerian about this approach and what is Lagrangian about this approach? A Lagrangian approach is one in which the observer follows an individual material element, such as an air-parcel, along its trajectory.*

As already discussed in our answer to reviewer 1, we will omit the term *Eulerian-Lagrangean* in our revised version.

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*A stream line is not the same as a trajectory, except in stationary conditions (i.e. local derivative with respect to time equal to zero).*

**Answer**: We are aware of the difference of the definition of a stream line that describes the instantaneous velocity field and a trajectory (path line) that describes the path followed by individual particles. We will carefully check the paper to ensure to not use them interchangeably.

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*The authors do not explicitly assume stationary conditions, although there is an indication that they are in fact doing this in equation (4) (page 8320), by assuming that ∂f/∂t=0. Equation (4), nevertheless, is introduced and explained inappropriately with the following text: "Equation (3) can be written in Lagrangean framework using the substantial or Lagrangean derivative". There is no explicit indication by the authors that they are actually assuming stationary conditions by assuming that ∂f/∂t =0 in equation (4) and ∂b/∂t=0 and ∂W/∂t=0 in equation (5).*

**Answer**: We have not made an assumption of stationarity. In the development of eq(4) we have not used the assumption $\partial f/\partial t=0$. The first equality in (4) follows from the chain rule applied to the total derivative of $f$ with respect to $t$, and the selection of Lagrangean coordinates, so that $dx/dt=u_x$, i.e. we are considering a parcel of air which is moving with the wind. The second equality in (4) follows simply from $\frac{\mathrm{d}f}{\mathrm{d}t}=\frac{\mathrm{dx}}{\mathrm{d}t}\frac{\mathrm{df}}{\mathrm{dx}}=u_x\frac{\mathrm{df}}{\mathrm{dx}}$. Neither of these equalities relies on an assumption of stationarity.

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*Another inappropriate introduction of an equation is the introduction to equation (1) (p. 8319): "The conservation of mass for M reads as: ". However, equation (1) appears to include a term describing diffusion of mass (the second term on the r.h.s.). With this term we are in fact studying a control volume that exchanges mass with its surroundings by diffusion. So, equation (1) should not be referred to as a mass conservation equation, but rather as a mass-budget equation.*

**Answer**: We acknowledge this comment but we do not think that this is a relevant concern (distinction between mass conservation and mass budget or balance). We would like to refer the reviewer to the introduction of the Wikipedia article on "Mass balance" (which certainly gives an excellent view of the current usage of definitions): " A mass balance (also called a material balance) is an application of conservation of mass to the analysis of physical systems".

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*Furthermore, the definition of M=VW, where the dimensions of V are [Lˆ3] and W apparently is dimensionless is not consistent with M being a mass. When I compare the dimensions of the different terms in (1), I conclude that, indeed, M=VW must have dimensions of volume. So, I guess my confusion is with the definition and meaning of "relative moisture filling", W, the most important variable of this paper! Clearly, W is not explained adequately.*

**Answer**: We appreciate this comment and apologize for the formal mistake; we will correct the revised version by adding the density of water. We will furthermore add the definition of relative moisture filling: "the ratio of precipitable water $C$ [L] to the maximum water holding capacity $c_{max}$ [L]".

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*The assumption on page 8324 that "for sufficiently small time steps (weeks to months), the change of soil moisture ∂S/∂t can be approximated with a constant rate of change" is crucial to allow a reduction of the problem to the solution of a first order (not a second order) differential equation (17). Except the comment about the time steps, there is no justification for this approximation, which is difficult to understand.*

**Answer**: The corresponding paragraph reads as follows: "Soil moisture is well-known to undergo a seasonal cycle of gradual filling and emptying, depending on the seasonality of precipitation and of vegetation growth. We, thus, assume that for sufficiently small time steps (weeks to months), the change of soil moisture ∂S/∂t can be approximated with a constant rate of change". We agree that his might not be sufficient as explanation. We will reformulate to:

"Soil moisture is well-known to undergo a seasonal cycle of gradual filling and emptying, depending on the seasonality of precipitation and of vegetation growth. We thus assume that this temporal cycle can roughly be described by a constant soil moisture increase during the wet season and a constant soil moisture decrease during the dry season, which translates into an approximation of ∂S/∂t with a constant rate of change."

Furthermore, we will correct "second order" to first order.

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*Another important assumption that is presented without justification is the assumption $u_x$=constant (on page 8324, line 11). This assumption, it seems to me, implies that the moisture content along a streamline changes at a prescribed rate, if b varies along streamlines according to the prescribed value of l (line 7 on page 8321) and conditions are stationary. If this is true, the problem is too strongly constrained to yield answers to interesting questions. The coupled system of two equations (14) and (15) probably has solutions that are much more interesting to reveal and study than the solution of equation (17).*

**Answer**: It could of course be very interesting to find solutions of the system of equations that do not need the assumption of a constant velocity field but at this point, we do not see how to find solutions in such a configuration (see also our previous comment on the assumption of constant parameters).